Environment on the Edge

2005/06

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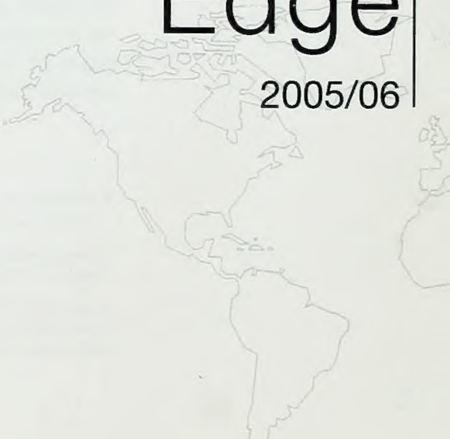

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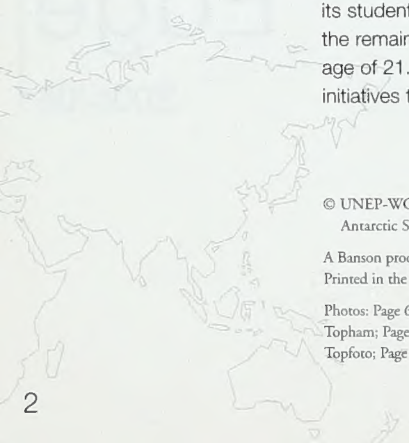

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UNEP WCMC

New Hall
University of Cambridge

St Edmund's College
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**British
Antarctic Survey**
NATURAL ENVIRONMENT RESEARCH COUNCIL

The lecture series, which continues in 2006-2007, is a joint collaboration between the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), New Hall and St Edmund's College, Cambridge University, and the British Antarctic Survey (BAS).

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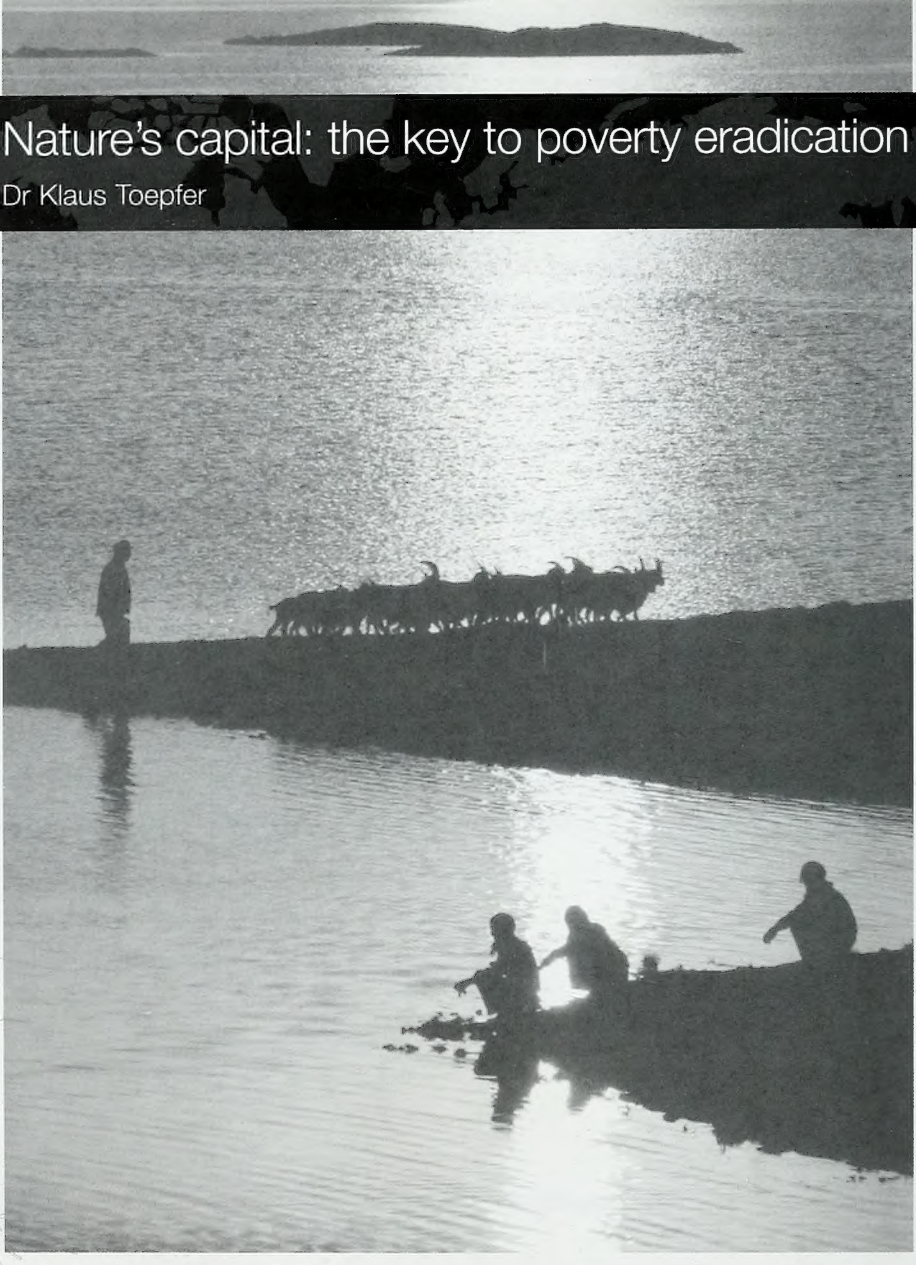
Nature's capital: the key to poverty eradication

Dr Klaus Toepfer

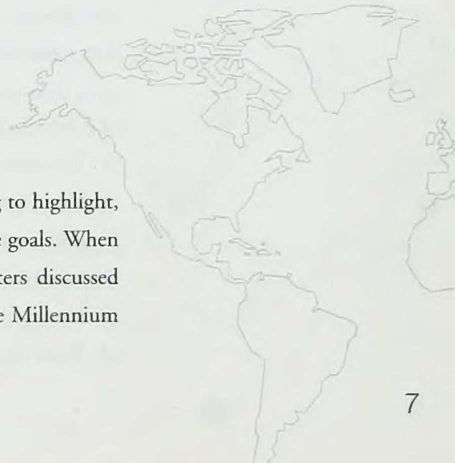


The year 2005 was quite an important one in the field of sustainable development and the environment. We witnessed focused activity concerning the interrelationships between the environment and poverty; and we saw the launch of the Millennium Ecosystem Assessment. We took what I believe is an important step forward by asking, together with more than 2,000 scientists from around the world: what is the status of nature's capital? Are we overusing it? What is the status of the different ecosystem services?

Incidentally, it was at the beginning of this millennium that we decided – for the first time – not to publish a new *Red List of Threatened Species.* This does not mean that we are no longer concerned with the responsibility of mankind for the diversity of creation and for species interrelationships. But it was crucially important to have the Millennium Ecosystem Assessment alongside the Millennium Project. Inspired by Kofi Annan, the Secretary-General of the United Nations, the Millennium Project is linked with the eight Millennium Development Goals (MDGs) agreed upon at the Special Session of the General Assembly of the UN in 2000 in New York by all the heads of state and government. The MDGs are fairly well known by now, but it is worth looking at them again. By 2015 all United Nations Member States have pledged to:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

Number seven – "Ensure environmental sustainability" – is the goal that I am going to highlight, but it is not an isolated one: the environment runs like a red ribbon through all of these goals. When UNEP held its Governing Council in Nairobi, Kenya, in February 2005, the ministers discussed exactly this topic: what is the contribution of the environment to the realization of the Millennium Development Goals?

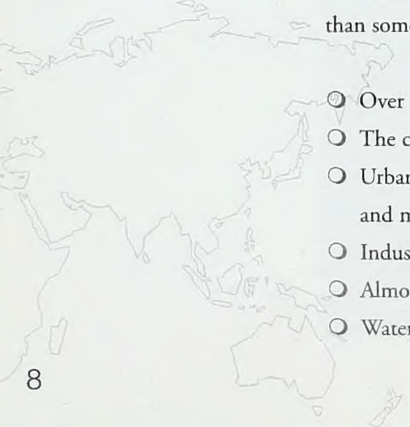


It would take too long to go through all the goals here, but each of them can be directly linked to environmental services. Goal 7 and the environment are not just important to those of us working in that specific area, but go much further.

The main topic of concern, and again one that interlinks with many of the others, is the first goal, "Eradicating poverty and extreme hunger". Even in this world of affluence, we still have huge differentiation between those with the most and those with the least to live on. The UN system uses, as an indicator of poverty, living on less than $1 a day. We could spend a whole semester discussing whether or not this is a good indicator but, in any event, it is the one we have.

In this world of 6.2 to 6.3 billion inhabitants there are some 1.4 to 1.5 billion living on less than $1 a day. The target is to reduce that number by 50 per cent by the year 2015, but we would still have 800 million impoverished people. If we then sub-divide the world, we find that in one part the main challenge is to fight obesity – here in the industrialized countries, children are becoming fatter and fatter – while in the other part of the world many people remain in a condition of hunger. With such a vast difference between the situation in one part of the world and that in the other, we need to consider what this means for global stability.

I want to show you some of the striking changes that have occurred over the last few centuries. I was recently in Tokyo discussing climate change, and among those present was Paul Crutzen, the Nobel laureate for chemistry, awarded for his contribution in linking the destruction of the ozone layer with specific chemicals, the chlorofluorocarbons. He had a wonderful list and it is from him, rather than some neurotic environmentalist, that the following figures have come.



- Over the past three centuries human population has increased tenfold to 6 billion.
- The cattle population has increased to 1.4 billion, or one cow per family.
- Urbanization has increased tenfold in the past century, so that almost half of the people live in cities and megacities.
- Industrial output increased 40 times during the past century and energy use 16 times.
- Almost half the land surface has been transformed by human activity.
- Water use increased ninefold during the past century to almost 1,000 cubic metres per capita. The

main use of water, taking up 65 per cent, is irrigation, with a strong interrelationship with food production, for example for rice production. A further 25 per cent of water is used by industry and approximately 10 per cent by households.

- The fish catch has increased 40 times.
- The release of sulphur dioxide through coal and oil burning is now at least twice the sum of all natural emissions. Over land the increase has been sevenfold, causing acid rain, adverse health effects, poor visibility and climate impacts due to sulphate aerosol particles.
- More nitrogen is now fixed as agricultural fertilizer than is produced by natural processes on land.
- The release of nitrogen oxide to the atmosphere from fossil fuel and biomass burning is larger than its natural inputs, causing high surface ozone levels over extensive regions of the globe.
- Several climatically important greenhouse gases have substantially increased in the atmosphere: for example, carbon dioxide by 30 per cent and methane by more than 100 per cent.
- The production of chlorofluorocarbon gases has caused major changes in the chemistry of the stratosphere, especially ozone loss, which has been particularly large in the spring over the Antarctic continent, the so-called ozone hole.

These figures demonstrate that extreme changes have taken place. The question is: are we overloading nature? Can we handle these changes in a way that permits stable development, and particularly in a way that avoids conflict? Conflict is a real threat. We, therefore, must seriously consider the effects of environmental change on poverty and the differentiation in this world.

We all know the shape of the physical world. Let us instead imagine how it looks when we size countries by other important factors. For example, what is the shape of the world if we take as an indicator the number of people under 15 years? Africa and Asia look very different, and very large; India is massive; and both North and South America, as well as Europe, are small and slim.

Then consider the shape of the world when we use GDP per capita as an indicator. This GDP-per-capita world is dominated by three large areas – North America, Western Europe, and Japan and South Korea – where GDP per capita exceeds $20,000 measured in purchasing power parity. Africa is now tiny, and comparing this Africa with the earlier one we get an idea of the huge differentiation – the instability in the world – particularly in the world of young people.

We can then ask how the world will be shaped in 2020, supposing that, for example, the economic growth rate of China remains at around 9 per cent, and that of India at 7 or 8 per cent, and that we will have an extra billion people on the planet by then. Africa will be more or less unchanged, while Latin America will have got smaller. This illustrates how necessary it is to overcome poverty.

In order to reduce poverty and improve economic development, three types of capital are necessary. The first is financial capital. We saw earlier this year Prime Minister Blair's initiative at the G8 meeting where Africa was the main topic discussed, and the Live 8 concerts and associated campaign to "make poverty history" – all based on bringing more financial capital to overcome this problem. Of course, in a country like China we find blocks to economic development, but, with reserves of some $700 billion, it is not financial capital that is hindering economic development in China.

The second capital needed is human capital. We need education – and if we go back to the MDGs we see that one of them is to achieve primary education for all, especially girls.

Most discussions up until now have centred around financial and human capital as the means to overcome poverty: that we also need nature's capital has often been forgotten. Let us take China as an example again. The Vice Premier of China came (for the first time ever) to our recent Governing Council in Nairobi, with a large group of people including four ministers. China is clearly aware that the bottleneck in the implementation of its decision to quadruple the country's gross national product is nature's capital, and that they now need to invest in it. Why is this bottleneck happening?

It is not difficult to explain from an economist's point of view. Many of nature's assets are more or less free goods, common goods. People have used them as much as they wanted with no immediate negative consequences. The air – the atmosphere – has been perceived as such, available for the disposal of all sorts of gaseous emissions. Few have asked whether this facility should carry a price or whether it should be limited. The same has been more or less true of water, particularly in those regions where it is plentiful. To some extent we have encountered a problem over this resource because economic development first came about mainly in those parts of the world where it is abundant, with the consequence that technological advancements have not needed to be water-sensitive. Where water is restricted, as we find for example on aeroplanes, a solution has often been found.

Nature has the capacity to absorb a certain amount of all kinds of waste: gaseous, fluid, solid, etc. But if you exceed its absorption capacity you realize that there is a limit, and a downside for human health. When we have a free good, and do not pay a price, then we need to be aware of what we are doing and consider the true costs.

The true environmental costs of development in the three regions with the highest per-capita GDP have been largely ignored – externalized. Economic development has been subsidized by overusing nature's capital both at home and abroad. This is why, in 1972, people started to question what was happening to the environment – which knows no national borders – leading to the United Nations Conference on the Human Environment and the birth of UNEP. It was then that environmentalists decided that we needed to work together to identify the transboundary consequences of overusing nature's capital.

Economic science has long been familiar with the idea of a "beggar-my-neighbour" policy. This happens when nations develop specific currency exchange-rate policies, or wages or other policies, that lead to their neighbours being the ones to carry the costs of such growth processes. We do the same with the environment. In many countries, all you need is the precise location of a land-fill or a high-emission manufacturing plant and you can work out exactly where cities and borders lie – such facilities tend to be located on a country's or city's boundary so that the wind takes the problems to its neighbours.

It is a familiar phenomenon, beggar my neighbour. But when people become aware that they are the beggars, they are not happy about it. Africa has a share of the global population of some 14 per cent, and a share of global carbon dioxide emissions of 3.2 per cent. But Africa is suffering most from climate change. So Africans could, of course, come to the industrialized nations and say: "Why are we paying for the fact that you cannot handle your carbon dioxide emissions? If you want to continue, you must at least back us in adapting to climate change." Externalizing the costs of our own welfare has consequences for the behaviour of others, and therefore for the overall domain of security in this world. This leads me to the fact that small island states, specifically Tuvalu, are already asking who will be liable should – or when – they become submerged as a result of a rise in sea level.

UNEP is headquartered in Nairobi in Kenya, in the centre of Africa, the best location we could ever have but not an easy one. There we are confronted with many of the major problems of this world – 75 per cent of the global population lives in cities like Nairobi, not in cities like Cambridge. We see poverty on a daily basis; we know what it means to have no sanitation and inadequate water. Therefore, our motto is "environment *for* development", not environment for environment, nor environment and development. Environment *for* development is sustainable development – the peace policy of today.

I will give you a few additional examples of the effects of unsustainable development. We can compare satellite pictures of the ice cap on the Arctic in 1979 and 2003, and we see that it has diminished so much that we will very soon find that the passage via the Arctic is open. You may have seen the *New York Times* of October 2005 showing pictures of what is happening in the Arctic – the opening of the Arctic, the melting of the permafrost, the decrease of albedo (reflectivity) – and the probability that this is directly linked to the non-linear development of climate change. There is enough material there for a whole lecture on its own. As we saw in the list from Paul Crutzen, there are changes going on, and these changes are reflected in the environment.

You could, of course, ask why we need ice in the Arctic. There was certainly once an Arctic with jungles. We also know that it is one of the world's biggest fossil fuel reservoirs. If you exclude the Arab countries, I think the Arctic has the same capacity as all the other countries with proven oil reserves together. I have heard people say how nice it would be to have the climate of the Mediterranean in, for example, Sweden, as there would then be no need to go to the Mediterranean. The problem is that such changes in fact have only losers and no winners, because the dynamic nature of these processes also has negative consequences: an increase in extreme weather conditions and so on.

Take water as another example. We know that water use is linked to population and development, and also to climate change. We can compare Lake Chad in Africa in 1963 and 2001. In 1963 the lake was a significant water body surrounded by four important countries: Nigeria, with the largest population in Africa, Cameroon, Chad and Niger. Each country had a large share of the lake. By 2001 parts of the lake had dried up while others were covered with vegetation. Water now extends over a fraction of the area it did in 1963, with none at all in Niger and Nigeria. In Chad, it occupies only a tiny proportion of its former extent, and even in Cameroon there is a far smaller body of water than previously.

Again, at the time of the Soviet Union the authorities decided to increase abstraction from the two rivers that fed the Aral Sea, for rice and especially for cotton production, which uses a great deal of water. Water was consumed in such quantities that none reached the Aral Sea, with the consequence that the sea has been gradually disappearing. In 1989-1990 it separated into two – the Large Aral and the Small Aral – and between 2000 and 2001 Vozrojdeniya Island joined the mainland to the south. Again, we have a common good not being correctly valued. Nature's capital is decreasing, with consequences for poor people in particular.

And finally, let us look at the Mesopotamian Marshlands. In 1976 these occupied a significant area linked to a specific group of people with a specific cultural identity, the Marsh Arabs. This is an instance of the interrelationship between biodiversity and cultural diversity, one we should underline much more. By 2000 all that was left of the marshes was a small area more or less in the transboundary region between Iraq and Iran. A number of people say that this was the first "ecocide" in human history; that in destroying the environment, the basis of existence for a specific group of people was also destroyed. Indeed, the Marsh Arabs could no longer live there. At UNEP we are working with financial help from Japan to revitalize these marshlands. There are many problems, not least because if we want to have marshlands again we need water, and the water we need there cannot also be available elsewhere. Nevertheless, there is much that can be done to stabilize the marshlands again. Once more, we have seen nature's capital decreasing, with consequences for the poorest people.

We must ask again whether we are valuing our ecosystem services correctly and must seek to introduce much more efficient technologies. The current problem with water is not that we do not have enough but that we do not have enough money to make sure it is recycled. We have an investment crisis, an administrative crisis and a technology crisis. How to use water better will soon become a question of survival, and therefore also a source of possible tensions.

One of our particular current interests is to stimulate discussion, new calculations and new methods to determine an appropriate way of measuring the growth rates of specific nations. Particular attention is being given to this by Professor Sir Partha Dasgupta in Cambridge. What, he is asking, is the realistic growth rate of China? If the necessary reinvestment in nature's capital were integrated into the calculation the picture would change considerably.

This is not just a technical issue. In a world that undervalues nature's capital, or does not value it at all, the losers are those who are producing nature's capital. And given that the main reserves for the production of nature's capital are in the developing world, we must conclude that we are not only decreasing the growth rate in developing countries but doubly burdening their economic and societal development.

The World Summit on Sustainable Development included mention of access and benefit sharing of genetic resources and indigenous knowledge, and we have a similar concern coming out of the Convention on Biological Diversity. The World Trade Organization and the World Intellectual Property Organization have a clear regulation known as TRIPS – the Agreement on Trade-Related Aspects of Intellectual Property Rights. This seeks to ensure that intellectual property rights are protected and that whoever wants to use someone else's intellectual property has to pay for it. This is now the accepted solution around the world.

But we do not have a TRIPS-like agreement for the rights of indigenous people with regard to their own knowledge; this knowledge is available at a zero price. Nor do we have any regulation concerning access to genetic resources, which are largely located in and maintained by developing countries. Genetic resources can be accessed free of charge, while the result – the intellectual property – is protected by a price tag. Understandably, many in developing countries believe this is unfair. People gain information from the genetic knowledge available in developing countries, use it and make products out of it, and then the developing countries have to pay a high price for the products, only possible because they once protected this biodiversity.

We are in the early stages of producing instruments on access and benefit sharing, but there is great interest in making them much more binding. There is already something like the "OPEC"[1] of biodiversity, consisting of like-minded countries of mega-biodiversity, initiated by Mexico and now I think chaired by India. These mega-biodiverse countries are saying that they should receive some form of linked payment for the use of their biodiversity by others.

We learnt from the Nobel prize laureate on economics, Joseph Stiglitz, that the calculated worth of the capacity of forests in developing countries to fix carbon is between $30 billion and $50 billion a year. But they currently do it free of charge. The question is: how can the interest of people in protecting their forests be increased? There is no point telling them they have no right to destroy forests that contain biodiversity and operate as carbon sinks, because they will reply that that is all very well but what is in it for them? We need a policy to ensure that those who produce these common goods also benefit from them. Interestingly, if those with forests cut them down they can then be paid to reforest the area under the Kyoto Clean Development Mechanism. But if they leave the forest standing, there is no compensation mechanism. We need to find a solution to this.

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[1] Organization of the Petroleum Exporting Countries

It is good that we are being pressed not to use timber from tropical rainforests – a number of non-governmental organizations have run campaigns on this issue. But we also need to persuade people living in forested countries of the value of their forests. Logs are currently exported to industrialized countries with almost no import duties imposed on them. But as the value-added chain lengthens, the import duty grows. As a result the potential for adding value is exported to the developed world along with the logs. There is nothing to encourage those in the country that produced the logs to appreciate the forest's value. Not only must we emphasize the importance of nature's capital and the fact that it is being overused, we must also make people understand how nature's capital contributes to world stability and find ways to change the situation.

Mexico has made a start, introducing the first pilot project to pay per hectare of protected forest, according to specific criteria for the forest canopy, in order to maintain the carbon sink it provides. Payment starts at $50-60 per hectare per year and goes up to $250 and more, calculated on the basis of the forest's value for fixing carbon and for watershed management. A country that has led the way in the watershed field is Costa Rica. Amongst other projects it has one in which the downstreamer pays the upstreamer to protect the forest in order better to manage the watershed. If upstreamers have no interest in protecting the forest, they are highly likely to change their surroundings and land use.

More such initiatives are on their way. Of course, this kind of undertaking is more easily accomplished within the boundaries of one country and is much more difficult if the area concerned is transboundary. But we cannot expect everything to be easy, and it is vital to take this course unless we want to see the next Millennium Ecosystem Assessment showing an even more disturbing picture than it does at present. Nature's capital has already been reduced to 60 per cent of what it once was, on average. If the lost 40 per cent had been used well, to overcome poverty – with the idea that we were seizing our chances and would make up for it later – it would be easier to understand. But we still have high levels of poverty; we still have a very worrying distribution of births; we still have the three ultra-rich areas contrasting with the rest of the world; and we are still pursuing a development path where nature's capital is not valued. We are going in a very risky development direction if we ignore these signals.

The most successful book we have ever made at UNEP (*One Planet, Many People: Atlas of Our Changing Environment*) was based on a very simple idea: we looked at specific places in the world and compared satellite photographs from the 1970s with those from around 2000. The book achieved tremendous coverage in newspapers around the world. Here are two examples from it.

The first is a region of southern Spain, which in 1974 was a typical rural agricultural area. By 2004 it was under glass. From the shoreline to the base of the mountain behind, some 20,000 hectares had been transformed into greenhouses to produce crops such as tomatoes, with an accompanying heavy demand on water. An ecosystem service – water – was redirected to irrigation in a region that is now experiencing periodic droughts, with implications for the economic situation as well.

The second example concerns the mouth of the Yellow River. Between 1979 and 2000 a giant animal-like head formed in the delta as a result of sedimentation, the effect of deforestation and wetland destruction upstream. This is one of the world's muddiest rivers, bringing sediments such as mica, quartz and feldspar from north-central China.

There are more examples – such as the development of Las Vegas – but these are sufficient to show that if we go on like this, we will find we are destroying the natural capital that we so desperately need to fight flooding, to maintain agricultural production, to store water and so on.

What is my message? Most probably my message is not as scientific as it could be, but it is that we must be aware that nature, nature's capital, is not a luxury for those who have no problems on their hands. Nature is a basis for fighting poverty. The poorer the people, the more they need nature's capital for overcoming poverty. You may have read the recent World Resources Institute report, *World Resources 2005 The Wealth of the Poor: Managing ecosystems to fight poverty.* If you have, and remembering *An Inquiry into the Nature and Causes of the Wealth of Nations* by the well-known economist Adam Smith, published in 1776, you realize that we really do have to recalculate the wealth of nature. It is not by chance that one of Partha Dasgupta's chief books – *An Inquiry into Wellbeing and Destitution* – has a title echoing this concern.

We have to reconsider nature's capital, not emotionally and not in a back-to-nature way, although that is necessary and helpful as well. Respect for nature is the basis for many good regulations. It is to some extent a pity that the only regulation of our use of nature's capital that we have at present goes by a dollar or euro sign. In previous generations it was also linked with spiritual values. Nobody had to ask the price of water because those spoiling it became social outcasts. If you examine the basis of all the big global religious beliefs, you find this spiritual respect. They do not need a dollar sign.

If we want to fight against the decrease in nature's capital, we have to go back to investment decision making. It is extremely important that poverty reduction strategies for developing countries integrate nature as a specific target. We must inform people that there is a higher return on an investment in mangroves than in the construction of a new dam; we learnt this in the tsunami. We have all the figures, we can do the calculations – and we must thank the economists for this, including David Pearce of the United Kingdom, who died some weeks after delivering his contribution to our Poverty Environment Partnership (a cooperation with the United Nations Development Programme and others), in which he linked poverty and the environment. It is essential to bring this information into the decision-making process for investment.

There is a nice example of investment decision making from our headquarters country of Kenya. In 1980, Kenya decided to construct a new dam – the Masinga dam – responsible for 50 per cent of the country's electricity production and for an even greater proportion of its water supply. In 1980 the capacity of the dam was more than 1.4 million cubic metres. Twenty-five years later the capacity is down to a million cubic metres, and inadequate, so there is now a call for a new dam. The underlying cause of the reduced capacity is huge deforestation, along with the disappearance of terraced coffee production due to the drop in coffee prices. These developments all resulted in a sedimentation and erosion process that has decreased the dam's capacity. Of course, we can now construct a new dam; we can follow the old development pattern with an increase in speed. But we can also now try to convince investors to look first at afforestation and improving wetland quality in the dam's catchment area. Only then should there be debate on whether there is a need for additional capacity. The decision should not be made in isolation.

We are blessed in Kenya: last year's Nobel peace prize winner, Wangari Maathai, well known for her work in planting trees, is working with us to try to convince people that investing in nature's capital would provide a better return than a new dam. Only if we can prove this do we have a fair chance of being integrated into the investment decision. Otherwise we will not be heard, because it is much more difficult to hold vested interests in the natural capital of forests and wetlands than in building a dam. That is not to criticize those who wish to invest in a dam: were I an industrialist, I would do the same in a comparable situation. So we try, step by step, to quantify environmental services, to draw up profiles for different countries, to evaluate where nature's capital is lacking and where there is a need for targeted investment, and to make this a common approach to poverty reduction because poor people, especially, need this help.

I hope that I have given you some useful ideas to think about. I was once a professor – and my family is convinced that this was the best time in our lives. But it is too late for me now. I can only, after retiring from the United Nations, go on to my balcony to drink a glass of wine and criticize the way the world is going. But as long as we have a chance to change this, let us join hands, for it really is worth it. It is investment in the peaceful development of our world.

Dr Klaus Toepfer
1998-2006, United Nations Under Secretary-General and Executive Director of the
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1994-1998, Federal Minister of Regional Planning, Building and Urban Development, Germany
1987-1994, Federal Minister of Environment, Nature Conservation and Nuclear Safety, Germany

Human development in China

Dr Zhao Baige

Twenty years ago I began my academic life as a researcher in Cambridge, and it is as an academic that I shall describe the progress China has made in human development.

I believe human capital is a crucially significant factor for a developing country. The world has before it a great opportunity to realize the promise of equality and freedom: all around the globe we can see the positive and active influence that globalization is having on human development. All societies have been influenced by the rapid progress of science and technology, especially information technology (IT), which gives people more information, more choice and more freedom.

China is the world's most populated country; indeed it has 20 per cent of the total world population. How does China interact with the international society, especially as it confronts both the rare opportunities and the severe challenges arising from population and human development issues? In China we are always looking for ways to further implement the Programme of Action from the International Conference on Population and Development and to realize the Millennium Development Goals, both at an international level and nationally. We reflect on how our country can respond to the opportunities and changes in the *xiao-kang* ("well-balanced" or "harmonious") society. This is a big challenge, not only for the politicians but for the whole country.

There is a consensus throughout the international community that in modern society individual happiness and well-being are not confined to the benefits arising from material prosperity, but also depend on having freedom of choice. They are linked to equality in development between one individual and another, and freedom for the overall development of the human being. Society as a whole also recognizes the need for harmonious balance between the individual pursuit of development and the social, political, cultural and economic components. Society, too, must ensure that there is coordinated development between people and the natural environment.

For these reasons, the world has begun using a different system of indicators – the Human Development Index – to evaluate the quality of development, to evaluate human life. Indicators for looking at human development include economic status; gross domestic product (GDP) per capita; poverty eradication; living standards, including housing and water supply and sanitation; educational status (in China, for example, we have nine years' compulsory education); adult literacy rates, and so on. Personal indicators like life expectancy, and health indicators such as antenatal care, maternal mortality and infant mortality are all now incorporated, as well as statistics on labour, employment, women's status and reproductive health: this last has become an important component in measuring human development. The indicators used for evaluating reproductive health include the total fertility rate, contraceptive prevalence and incidence of HIV/AIDS.

What is the situation today in China? Let us compare the rankings of different countries on the Human Development Index. On this indicator, Norway ranks first, and is followed by a series of industrialized countries. Sierra Leone is bottom, in 175th place. China today is in 104th place. There are a number of reasons why my country, in spite of its very rapid economic development, is still in the middle ranks.

If we look at population statistics, we see that China has made great strides in improving life expectancy and lowering infant mortality. Take the infant mortality rate first: for the world the average is 54 infant deaths per 1,000 live births, and for the most developed countries it is 6. In Asia as a whole there are 51 infant deaths per 1,000 live births, but for China the figure is 27. Again, on life expectancy China does well among Asian countries, with a life expectancy of 72 years, compared with 68 for Asia as a whole and 67 for the world average (the most developed countries have life expectancies of around 76 years). The total fertility rate in China, too, matches that in the most developed countries, at 1.6 children per woman. This compares with averages of 2.7 children per woman for the world and 2.5 children for Asia.

Urbanization, however, is still very low in China compared with the rest of the world. In China, 37 per cent of the population live in urban areas, while the average for Asia is 38 per cent and for less developed countries 41 per cent. (In the most developed countries 76 per cent live in urban areas and in the world as a whole, 47 per cent.)

We can compare China with two industrialized nations, the United Kingdom and the United States of America. China today has the biggest population in the world, at 1.3 billion. The population of the United Kingdom is 60 million and of the United States 297 million. But China's population density is more than four times higher than that of the United States: 137 per square kilometre against 31. This figure conveys the idea that China not only has a very big population – and every year we have an increase of 7-8 million people – but that the country is quite densely populated.

Other comparisons with the United Kingdom and the United States show that all three countries have similar birth rates – 12 births per 1,000 of the population for China and the United Kingdom, and 14 for the United States – although the latter has a higher total fertility rate, at 2 children per woman compared with 1.6 for China and the United Kingdom.

Turning now to China's economic development, there has been rapid economic growth since 1990, with a dramatic increase in gross national product (GNP), which reached 9,023 yuan ($1,100) in 2003, a more than fivefold increase on the 1990 figure. Between 1984 and 1993, gross domestic product (GDP) grew by about 9 per cent each year and between 1994 and 2003 by about 8 per cent each year, indicating the very real improvement in the economic situation.

However, these figures hide some significant differences between urban and rural areas. The average net income of urban residents quadrupled between 1990 and 2003, but growth was much more modest for rural residents, whose income in any case was much lower. Another qualification to China's economic success is the amount of public expenditure going to social, cultural and educational development. This remains at only 5.5 per cent of GDP, against 4 per cent in 1990, and we should regard this allocation as a very low investment in social and cultural development.

The disparity between different sections of society is worrying, especially as in some respects it is increasing, and may signal the possibility of potential social unrest. Not only are there growing inequalities between the urban and rural areas, but also between the eastern and western regions, and between men and women. While the estimates vary, the Gini coefficient (a measure of inequality in which 0 equals perfect equality and 1 equals perfect inequality) now stands at 0.44. To give one example, the proportion of villages with a clinic dropped from 87 per cent in 1990 to 74 per cent in 2003.

We can also look at some recent demographic data. China's population was 1.29 billion in 2003, and due to reach 1.3 billion in 2005. At the same time the population structure shows some signs for concern. The percentage of the population over the age of 65 is currently about 7 per cent. The sex ratio at birth is rising: it was 111.3 boys to every 100 girls in 1990 but in 2003 was 117. There is now a large migratory population of about 140 million. This has been called the biggest migration in the whole world, and how the government manages this group in terms of education and public services, and goes about managing the younger generation, presents a very big challenge.

China has made great progress in improving the health of its population. Not only has life expectancy increased (by three years since 1990) and infant mortality dropped (from 50 infant deaths per 1,000 live births in 1990 to 25.5 in 2003), maternal mortality has been falling as the number of hospital deliveries has risen and the contraceptive prevalence rate has increased. The maternal mortality rate is now 51.3 deaths per 100,000 live births, compared with 88.9 in 1990. Eighty per cent of deliveries take place in hospital, up from 50 per cent in 1990. The contraceptive prevalence rate is now 87 per cent.

However, we now have to face several new problems, especially HIV/AIDS. Today in China we have 840,000 people infected with HIV/AIDS, and this figure is expected to grow to 10 million by 2010 unless extraordinary measures are taken. Another current concern is that medical services in the countryside and rural public health services have declined. Thirty years ago China had an excellent system of "barefoot doctors", but they have gradually disappeared. Services in the countryside have suffered as more attention has been given to health services in the cities.

Although there have been great improvements in education, there is still a need for more investment in this area in China. Since 1990 there have been positive signs in an increase in the adult literacy rate, from 77.7 per cent then to 89.1 per cent in 2003. In particular, the literacy rate of 15-24 year olds is a pleasing 98.6 per cent. However, education expenditure is still very low. In 2003, investment stood at 3.28 per cent of GDP, up from 2.85 per cent in 1990, but still not enough. This proportion is below international standards and also below the government's goal of 4 per cent for 2003.

What about the situation in gender equality? One indicator, the proportion of seats taken by women in the national congress, is reasonable, at 20 per cent, a figure which has been stable since 1990. The ratio of women to men aged 15-24 years who are literate is satisfactory, too, at 95 per cent. However, we have two important problems concerning gender equality. First, the sex ratio at birth is skewed in favour of boys, with an unusually higher number of boys born than girls. Secondly, we find that of all the school-age children who withdraw from school after two or three years because of family issues or the economic situation, and go back to the family to work, most are girls. As far as gender issues are concerned, therefore, we must look not only at the seats of power and the political situation but also at the status of girls and women, especially in the countryside.

The environmental situation is a big issue in China. High population densities and the demands created as a result of rapid economic growth over the last two decades have put considerable pressure on the environment. It is reported that more than 90 per cent of China's grasslands are degraded and several cities are cited as among the most polluted in the world. Both arable land area per capita and freshwater resources per capita are declining, while energy consumption per capita is going up at a significant rate. Protecting the environment is an enormous challenge for China.

The last area of human development I want to cover is the extremely important one of employment. As already mentioned, 7 million new people are born every year, and the same number are also entering the labour market. In 2003, nearly 7 million new employees began to work in different fields. The unemployment rate in urban areas stands at 4.3 per cent (against 2.4 per cent in 1990). Although there has been a rise, China is in quite good shape compared with Germany, except that in Germany there is a somewhat different concept of what employment means. For example, a lot of farmers who work in the countryside feeding their chickens have a stable job, but when we measure employment we really mean that you not only have a very stable job but also good pay for that job.

In China, 64 per cent of employment is still in primary industry, though this proportion has shrunk from 72 per cent in 1990. But it means that a lot of manufacturing work is still using muscle, not technology. The remainder are employed in secondary and tertiary industry combined. In the future, especially the next ten years, I think there will be major changes in these fields of industry, and China is well prepared for this.

Now we have looked at this background data, I want to turn to China's accomplishments. I believe China has already become one of the strongest developing countries, strongest because it has been the fastest to change. When we use the term "developing countries", we are talking about a widely different range of countries, some of which are still very poor. In China, 200 million people have got out of poverty, per-capita economic growth has reached 8-9 per cent a year, and about 70 per cent of the population now have a standard of living better than that of other countries in the world. The eradication of poverty is a great success story for China. In addition, life expectancy has been extended to 72 years. However, the Human Development Index still puts China in the category of a medium level of development. The reason, as I mentioned before, is the imbalance between regions, between east and west, and between men and women.

China still faces serious challenges, and I have already referred to some of them. I believe the government is deeply concerned, firstly about growing inequality, and secondly about the large number of poor people, especially in rural areas. Today we still have 30 million people who are living below the poverty line and many who remain outside social safety nets. Other issues include the addition of 7 million extra people to the population each year, the 140 million internal migrants and the 840,000 people infected with HIV. We also have a steadily ageing society. In the UK and other European countries, many demographic and social developments evolved gradually, with the change from high to low fertility taking place over a span of perhaps a hundred years. But in China it has happened in only 30 years. And the ageing society is coming – to repeat, 7 per cent of the population is currently over 65 years old. A further challenge is the pressure that China's high population density and rapid economic growth are putting on the environment.

Decision makers have a difficult time when it comes to population issues, having to balance three different levels: the macro level of population and the environment, the level of resources, and the level of individual rights in which people want more children and big, happy families. The government is aware that the environment needs protecting and that resources are lacking. But without an adequate social security system or enough opportunities for people to work and pay for the necessities of life, how can the government ask its citizens to have only one child?

We have carried out an in-depth study of why the ratio of boys to girls at birth has gone up, and there are a number of reasons for it. First, family policy presents a challenge to the people. This may be one reason, but it is not the only one, as we find quite high ratios in other countries that do not have similar family planning policies – India, the Republic of Korea and Singapore, for example. I think in India in the 1990s the boy-to-girl ratio reached about 113, but today in China it is a high 117. We have identified several other factors. There is the cultural reason that people prefer to have a boy; there is the fact that in China the social security system is poor, especially in the rural areas; and thirdly, when family size is limited to only one or two children, parents prefer to have boys to provide strong labour.

What actions does the government intend to take on this important issue? It will try to form a social security system, especially covering the countryside area. We will gradually enlarge coverage for the rural areas, with local and central government each contributing a third of costs and the people themselves the remaining third. We are still at the pilot study stage and I hope later on it will improve. A second action we want to take, as with education, is to use social policy to make it easier for girls to have land, a house, and equal rights with boys. There is now in China a large programme called "Girl Care", through which the government is trying to educate people to value girls as well as boys. Things are changing. I can give you an example. Two families in a village were fighting over rights to some land. One family had two boys and the other had two girls. The boys' family tried to use muscle to secure the land but the girls' family took the case to court, and won.

The government has to consider three points in its decision making. First, with respect to human development, there must be greater education and greater opportunities for people, especially for women, and people have to recognize why this matters. Second, the new generation must appreciate the importance of taking responsibility for children, rather than having a large number of children who just survive, with barely enough food or clothes. And at the same time the government has to think about the macro level and ask people to limit their families in order to be able to balance the various needs, to provide education for everyone and to protect the environment.

As China faces all these challenges, we must always consider what is the right way to deal with them, and what are the true principles on which we should set our new strategy. In this respect, China has adopted four important strategic principles. The first is that we believe that "development" refers to comprehensive development, of the economy, society and culture. In future we will use human development indicators rather than just GDP to assess development. Some 25 years ago the only evaluation system for development was GDP, but now these other indicators are coming much more to the fore.

The second principle is that it is the individual human being who is the subject, participant and beneficiary of development. People's well-being and benefits should be the most important parameters for developmental achievements.

Thirdly, in the next ten years or more, we believe that in our pursuit of development equity should be stressed. We will pay more attention to the poor, and to disadvantaged areas and sections of the population, including women, children, the elderly, the disabled and rural migrants.

The fourth and final point is that we believe that the government is the prime promoter of development. They own the resources; they have the power to promote the whole society. However, the government is not the only player in development: we would like to involve the whole of society, including the government, non-governmental organizations, citizens, enterprises, the media, everything which we define as part of civil society. The most important transition in the 21st century is realizing that the whole of society can no longer depend only on government. There are so many needs and demands and the government must now work with civil society.

There is a relationship between people's rights and needs and how these are met, and in China I believe we now feel that people's rights and needs should become the top priority in the whole system, because it is not possible to promote development and make everybody participants and benefactors of development without considering people's rights and needs.

One of the important changes of the 21st century is the rapid development of technology – especially information technology. In China this year, we have 120 million people using mobile phones and 60 million people using the Internet. While, in the past, it may have taken six months for information to spread, it is now transmitted straight away – to villages, families and individuals. A good example of this occurred on 11 September 2001: overnight, information about the attack travelled not only to urban areas but also to rural ones. A society such as this cannot depend on only one power, the government. The more information there is, the greater are people's requirements:

another reason why the government cannot operate in isolation but must also use the resources of civil society.

In China, civil society has progressed, though there is still some way to go. There will be more space, freedom and representation for individuals. We can say that we are halfway and are heading in the right direction. We have an idea of what perfection would be, and can look at the process of achieving it. Civil society has three important functions: first, to represent society's citizens; second, to help monitor and check the system of government; and third, to limit the government's powers. Civil society is gradually coming to play an important role in China.

And how is the government working? Some of us are currently studying in Cambridge University and we feel very excited about the principles of good governance. As you know, responsibility, legitimacy, accountability, transparency, the rule of law and efficiency will in the future, if not today, become the guidelines for the government to be a good government.

Our government system is working to provide a good service in terms of public goods and information. We believe that in the future information will itself become power, a resource for the people. If we can provide more information, people will have more choice and so have more freedom. As for the government, in the future we will be continuing with our work on planning, regulation, investment and, of course, evaluation.

Finally I should like to quote our President, Mr Hu Jintao. He said: "Social harmony and a happy society is an ideal that mankind has always aspired to." We recognize that here we have a perfect goal; we recognize that we may never attain perfection, but it is our mission to progress towards that perfection.

Dr Zhao Baige, Vice Minister for Population of the People's Republic of China.

Agriculture and food production: Quo vadis

Dr Hans Rudolf Herren

Why should we be concerned about the agricultural production base? First, the world population continues to grow: from less than 3 billion in 1950 to 4 billion in 1975, reaching 6.4 billion in 2006, and we expect it to be about 8.5 billion in 2050. Meanwhile, the area of farmland has remained roughly stable, as land lost to degradation and desertification has been made up by clearing forests and bringing land under cultivation through irrigation. But the future of food production remains uncertain, especially in view of global warming: much of the productive agricultural land in coastal areas is predicted to disappear. And more people means diminishing cultivated land available per person for food, fodder, fuel and fibre, so the pressure to increase the productivity of every hectare to achieve the same production levels remains high. Yet that comes at a cost.

In an ideal world, a well articulated understanding of pressures, drivers and appropriate responses would foster a decision-making arena in which national governments could work to increase or maintain agricultural productivity while conserving environmental quality. Between policy and farms, however, there exist a number of problematic "disconnections" that hamper good policy making.

Disconnections

Of the several disconnections in our systems we will discuss those between agriculture and the environment, between producers and consumers – or, in another sense, between rural areas and cities – and then between policies and expectations.

Agriculture and the environment

No matter how well we manage our agriculture, we are interfering with natural cycles. Contemporary farming methods in particular – with level fields, reduced biodiversity, no rest periods and the use of toxic chemicals – involve managing land in ways that conflict with the healthy functioning of ecosystems. Yet agriculture depends on healthy ecosystems for its water supply, for the cycling of nutrients in soils, and for pollination and pest control. We know all this, but rarely work to promote them. Some are trying: a number of farmers are moving to organic agriculture, sustainable agriculture, or ecoagriculture – whatever we call it – but this is only a tiny proportion of what is happening in agricultural production today. In contrast to the growing need for a system that works and will continue to work in the future, we are actually destroying it.

We are pumping water from very deep down and in many places the water table is receding below its capacity to fill up again; the cycle of nutrients in the soil is being broken because so many crops are exported far from where they are grown, with nothing being returned to the land where they are produced; we have an almost global problem in our loss of pollinators; and we are destroying the balance of natural pest control. In an environment that is functioning in a certain equilibrium, these systems operate almost without anyone noticing. It is only when changes begin to occur that we realize that something has been lost. We must ask ourselves what we want for the future. Do we want more land-degrading methodologies or do we want a sustainable approach to agriculture and food production?

Soil fertility: As we deplete soils through inappropriate practices, we have to compensate by adding fertilizers, creating new problems further down the chain because fertilizers, particularly nitrogen, have a habit of running off. The application of inorganic fertilizers is particularly heavy in highly developed areas such as North America and Europe, and usually where agricultural production is intensive. Africa in particular has not followed that trend so far, mostly for economic reasons, and that is perhaps one reason why productivity there is rather low. But across the world, soil degradation is now so severe that yields on about 16 per cent of agricultural land have diminished despite the use of optimal fertilizer rates. Soil productivity is declining in parts of India and the whole of East Asia. Again, the damage is greatest where there are major concentrations of people. Research in Thailand has shown there is no way to increase rice production with higher fertilizer application rates. The land is just exhausted, and there is a need to look at sustainable agronomic practices to maintain or increase yields. One such method, the System for Rice Intensification (SRI)[1], which originated in Madagascar and has been widely tested in Asia, takes advantage of specific plant traits to optimize growth and productivity.

Water use: Irrigated agriculture – a significant component in the productivity gains of the Green Revolution – is very important, but we need to think more about how we actually do it. Large-scale schemes often produce more food than we actually need, or produce it in the wrong places, and contribute to waterlogging and salinization, to the chemical contamination of surface and groundwater supplies, and to their untimely depletion. Such a loss of water means that there is no long-term future for this type of system. But there are better technologies, such as drip irrigation, which uses less water, helps to control weeds, resulting in lower herbicide use, and involves much less leaching of fertilizer, as water and nutrients can be directed straight to where the plant needs them. Far more must be invested in such technologies as

[1] see http://ciifad.cornell.edu/sri/listservs/index.html#update

part of sustainable agricultural research; we still have more to learn to become water efficient, and we still have to value water more highly. At present water is simply too cheap to promote such investments.

Agricultural chemicals and pest control: Runoff from high-use areas generally carries heavy loads of pesticides/herbicides as well as fertilizers, polluting waterways and overloading them with nutrients. Such high chemical loads have created problems for the people who want to use the water, and have also promoted pesticide resistance. There are now more than 400 herbicide-resistant weed biotypes, 150 resistant fungi and bacteria, and more than 500 species of insect, mite or tick that are resistant to one or more pesticide compounds. So many insects are resistant that in many cases we do not know what to do next. But this could be a good thing, because there are other ways of controlling pests: we can use biological controls, we can use better habitat management practices, and we can farm using fewer monocrops and more mixed cropping, which allows natural enemies of crop pests to be part of the system and stop them getting out of control. If we have an environment that is diverse in the sense of different guilds (herbivores, predators, parasitoids), we will have fewer problems.

Pollination services and beneficial insects: Recent research has shown that the most effective pollinators (representative of beneficial insects) are the first to suffer local extinctions under systems of conventional, rather than organic, agriculture. We are losing many of our pollinators, some we do not even know about. As an example of the many pollinating insects, let us look at the honeybee. In California people are currently paying $120 to pollinate an acre of almond orchard. Last year it was $30. This huge increase in cost is because hives in the United States, Europe and elsewhere are dying out as a result of the *Varroa* mite, which has been carried round the world by inattentive people taking short cuts. But there are many species of wild bee that have also disappeared, or are disappearing, because we are removing their natural habitats. Campaigns to preserve hedgerows are not just important for small animals but also for maintaining pollinators. About two-thirds of our plants need pollinators, so any loss in pollinators means a huge loss in plant biodiversity. If we continue to spray chemicals and remove hedgerows and natural habitats for wild bees, we are going to run into more and deeper ecological problems.

Genetic simplification: Another reason why pests have become such a problem is the planting of genetically similar crops, so that if a crop gets a disease it can be wiped out almost immediately. This is especially true for many hybrid plants. In the United States in the mid-1970s, for example, the whole crop of hybrid maize was lost and it was only because scientists were able to multiply new seeds off-season in South America that farmers could resume growing maize the following year. Vegetatively multiplied crops are a very strong target for cloning and tissue culture multiplication methods (e.g. bananas, cassava, many tree species, flowers, etc.). The narrower the genetic base, the more exposed the crops are and will be.

Producer and consumer

Now let us look at another disconnection, that between the producer and the consumer, or between land and cities. Consumers want perpetually low food prices (making farming a precarious business), but this is now compounded by a crisis of trust fuelled by food scares such as "mad cow" and foot-and-mouth diseases, and a sense that many supermarket foods are low on nutritional value and high on price.

In the case of "mad cow" disease, it seems clear that money was the issue behind the short cuts that created the problem. Now bird flu is coming; it is getting closer and it will be difficult to stop or even contain. The only question here is *when* it is going to happen – not *if*. And with animal-to-people transmission already occurring, it is probably only a matter of time before we have people-to-people transmission. Again the production system, fuelled by the "cheap food syndrome", is at fault. One may wonder why food is so cheap in the industrialized countries at a time when people have more money than ever, and health problems linked to nutrition have been demonstrated over and over again.

Industrialized agriculture is giving rise to increasing incidences of food-borne illness. We eat too much, we eat the wrong mix of food, and we get sick from our food. The concentration of livestock into factory-type feed lots, broiler sheds and massive piggeries promotes infection and spread. For example, more than 90 per cent of pig herds and 50 per cent of cattle in Denmark and the Netherlands are contaminated with *Campylobacter*, a food-borne bacteria causing diarrhoea. About half of the antibiotics used in the United States are fed to livestock, and four-fifths of these are to promote growth and suppress disease rather than treat it. Resistance to antibiotics is on the rise and, although until now we have been able to find new ones, we do not know how often we can do this or how quickly – not to mention the question of cost or who will pay for it.

As a result of these intensive methods, meat is cheap per kilogram produced, but if all the costs were factored in – water pollution, disease, subsidized transport of feed from Argentina to Europe, to the

United States or China – the meat would actually be more expensive than from a local farm with a mixed crop-livestock system. The same is often true of intensive grain production. Calculations of rice cultivation in the Philippines have shown that costs are greater, in terms of agricultural inputs involving high pesticide use, than under integrated pest management (IPM). Here too there are significant health costs, with increased incidence of eye, skin, lung and neurological disorders, not to mention costs to the environment and biodiversity. Clearly, many aspects of these food systems are unsustainable.

Policies and expectations

Almost every country in the world cherishes its agricultural roots, in song, picture and mythology. We believe that agriculture is a pleasant occupation and that it helps support our beautiful landscapes. But this valuation is rarely translated into policy to support the family farms that are central to any particular farming community. In many places agriculture no longer looks very nice, while in others much of the land has been filled with houses. Suburban sprawl usually takes place on the best agricultural land, and is followed by the requirement to intensify production on the remaining, poorer quality land, using more fertilizers and more pesticides, and so increasing productivity at a very high cost while also harming the environment and reducing the ecological services that a well functioning system can provide.

There are very few policies aimed at keeping good farmers on the land producing good food at prices that reflect the value we attach to safe foods and a strong rural sector. Agricultural subsidies have rightfully earned a contentious reputation, as they have too often served to support large industrial farms (certainly in the United States) and to help such producers flood developing-country markets with subsidized products, none of which achieves desirable policy aims. Moves within Europe to provide subsidies to farmers to maintain the environment rather than overproduce deserve further consideration, as well as close monitoring to ensure they are not subverted by conventional subsidy schemes. Nascent efforts to apply similar strategies in developing countries, such as Uganda, also merit close study.

Alternatives (two ICIPE approaches)

Improving the production base

There are viable options for stewarding the production base while maintaining or increasing agricultural productivity, many of which have been developed under the challenging conditions of developing countries. I will highlight two good examples of “green” but productive agricultural systems from the International

Centre of Insect Physiology and Ecology (ICIPE) in Nairobi, where I have spent the last 10 years: tsetse and trypanosomiasis management, and an integrated maize system for sustainable crop health management.

Tsetse control: Sleeping sickness, trypanosomiasis, is transmitted by the tsetse fly and affects animals as well as people, and cattle in particular. For people, the chances of getting the disease are generally very low, although in some areas of Sudan, particularly the south and a swathe through the central part of the African continent, it is quite widespread. Trypanosomiasis is not very pleasant, and once a person has it there are only very old treatments available to cure it, if it can be cured.

Nagana, as the form that has an impact on livestock is known, affects the whole sub-Saharan Africa belt. There are several species involved and the pathogens are all equally deleterious. In 1998 the Food and Agriculture Organization (FAO) of the United Nations wrote: "Nearly 100 years of control efforts have failed to curb the distribution of tsetse fly infestations or the resulting incidence of trypanosomiasis in Africa (only 10 per cent of the area reclaimed). African trypanosomiasis remains a major constraint to livestock productivity and continues to impede intensification of crop-livestock systems across vast areas of Africa that hold the greatest potential for increased agricultural production and rural development."

Tsetse flies breed in the undercover of bush. In the colonial period, control was undertaken in many regions of Africa by whole-scale bush clearance. This made it possible for farmers to raise cattle without high levels of tsetse, but after independence, when clearance was stopped, the land went back to bush and the tsetse flies returned. This has made it very difficult for farmers to farm, because they have no tractors and very little mechanical energy, so are dependent either on human labour or animal traction. And the problem is exacerbated by malaria, which leaves people too weak to work. A third of the working time of an average African is lost to malaria, amounting to losses of $12 billion a year. This toll of animal and human disease leaves many African farming systems with very little energy for production. Mechanization has been advocated, but is usually beyond the resources of African farming communities – and judging by current oil prices, will continue to be so.

Tsetse has sometimes been called a "blessing" to wildlife conservation, with the claim that if it were eradicated, cattle would wander everywhere and there would be no national parks or wildlife. This view rather fails to understand that cattle have been a part of African landscapes for thousands of years. An integrated approach, that seeks to manage rather than eradicate tsetse fly populations, is far more desirable than either continued high losses or old bush-clearance control systems.

There are a number of possibilities. One control method, the sterile insect technique, has been tested by the International Atomic Energy Agency in Vienna and by FAO. In this approach the tsetse flies are multiplied in the lab in their millions and sterilized with a cobalt radiation source. Once released into the wild, the sterile males copulate with the feral females with the result that there are no offspring. This has been carried out successfully on the island of Zanzibar in a forest of about 16 square kilometres, albeit at a cost of something like $30-40 million. Some think we can now do the same on the continent, but, taking an area such as that from Dakar to Maputo, many thousand times the size of Zanzibar, the cost would be somewhere around $10-20 billion, even if it were feasible.

Rather than trying to eradicate the tsetse flies, scientists at ICIPE have taken a bottom-up approach – and one that is sustainable – by enabling farmers to manage fly populations using traps and repellents, assisted by computer simulation models to identify where the traps should be placed. It so happens that flies are very much attracted by cobalt blue colour and so they come from far away and land on the trap, a piece of blue cloth with a plastic bag on top. The flies are trapped in the bag and die, frying in the sun, and the traps are then emptied by ants that like to eat the flies, making it a self-sustaining system.

This "pull" method – of attracting the tsetse – was not always sufficient by itself, so ICIPE developed a "push" or repellent technique. When thousands of flies were checked to see what blood they had taken, traces from elephants and every other kind of animal were found, but never any from a waterbuck. The scientists set about finding out why, especially as there are often more waterbucks than any other animal in the bushy riparian areas where tsetse flies breed. Waterbucks turned out to be highly repellent to tsetse flies. So the odour of the animal was synthesized in the lab, and the cattle now wear collars with dispensers that make them smell like waterbuck. Flies simultaneously avoid the cattle and get caught in the traps under what is called a "push and pull" system.

This all sounds very simple, but are farmers actually doing it? We tried it with the Masai and others, and found that as long as scientists were there to help they were happy to maintain the system but, a year or two after the scientists left, when the traps grew old and the farmers had no money to buy new ones, the system faltered. (In addition, people like to use the blue cloth for shorts and shirts, and they also make very good school uniforms.) However, when the farmers later realized that the traps had actually reduced cattle mortality, they began to put them out again.

People have been taught to make the traps themselves, but they still cost around $5 or so each for the cloth and so on, and this for many farmers is quite a large sum of money. Until recently, ICIPE recommended using one trap per square kilometre, which was successful, but generated a lot of work for the farmers who had to go to many places on foot. To reduce the number of traps, and so the costs and time burden, ICIPE developed a computer model to assist in the trap layout scheme. Control or monitoring traps from which the farmers collected data biweekly were placed in the target control zone. The resulting data were then processed and the computer model indicated where traps should best be placed to guide control operations to the predicted hotspots.

The number of traps used to limit tsetse flies is now down to a quarter of the earlier number, at levels manageable for farmers. Those involved in the project in the Ghibe Valley of Ethiopia are very enthusiastic, and the project has also attracted farmers from a neighbouring valley who requested training in the deployment of the traps. We call the system adaptive management, and it involves the farmers with the scientists and the extension specialists from the outset of the implementation process. They are taught how to place, monitor and control the traps, and eventually continue with the work on their own.

The project has now been going for three years with no outside interference: milk production has increased fourfold and ploughed land sixfold. In the past, most farmers had to get new oxen from the government almost every season, but now that cattle survive and do well, much more land can be worked. These are important implications for places like Ethiopia, where there are frequent famines and not enough food is produced, and where it is impossible to improve the situation if people do not have the energy to work and there are no animals to replace or help them. How much food would we produce in the industrialized world if we had to do it all by hand? Much of the efficiency of our agriculture is due to increased energy input.

Integrated maize cropping: Maize cultivation is expanding worldwide, very much so in Africa but also in Asia. Even though it is not a particularly good human food, it is replacing other crops because it is easy to grow, easy to consume, and requires little energy to cook. However, there are still some problems, including many species of stemborers, which attack the plant's stem so that it falls over or produces very little. Such attacks can reduce the maize crop by 15-40 per cent.

There is also a problem with striga, a major weed. The landscape looks very beautiful when covered with purple striga blooms, but the plant is a parasite that takes all the nutrients from the maize. This happens almost throughout Africa: it has been a major problem in the west, centre, east and south of the continent. The average reduction in yield is 10-20 per cent, but in many areas the loss is much greater, sometimes wiping out the whole crop, particularly in places where the soil is poor or the water balance is upset. Lately, Africa has experienced many droughts, compounding the striga problem.

ICIPE has been working with the Agricultural Research Institute in Rothamsted in the United Kingdom to look at ways to control both the stemborers and the striga. In the first stage the scientists were looking at the preference of *Chilo partellus*, a stemborer accidentally introduced from India, for laying its eggs either on the native African Napier grass or on maize. The finding in five different locations from Uganda to the Gold Coast was that more than 60 per cent of *C. partellus* preferred to lay eggs on the grass, even though larval survival is much lower than on maize: less than 20 per cent of larvae survived 30 days from hatching on Napier grass, compared with more than 70 per cent on maize. This finding provided us with our first piece of the jigsaw puzzle.

A second piece of the puzzle was that a much higher proportion of stemborers was affected by parasites when maize was intercropped with *Melinis*, a fodder grass. Although there was a significant difference in parasitization between the two study areas, in both cases it was lower in the maize monocrop than in maize intercropped with *Melinis*, whatever the ratio of maize to *Melinis*. The reason for this is that *Melinis* attracts beneficial insects into the maize field, particularly the parasites that attack stemborers.

It was also discovered that if *Desmodium* – a legume widely grown by farmers as a fodder crop – is grown in a maize field there is almost no striga. Although there are still questions regarding the *modus operandi*, the germination of striga is highly affected by the *Desmodium*. This provided us with yet another piece in the puzzle.

ICIPE scientists now needed to rearrange the pieces of the puzzle to improve matters. The proposed management system for maize cropping involved both push and pull elements. Around the field Napier grass was planted as a trap crop to attract the *Chilo partellus* moths. Inside the main crop rows, the role of *Melinis* was to repel moths and attract natural enemies. When the stemborers land, they prefer to lay their eggs in the trap crop, and the few that get to the main crop are pushed out because they do not like the smell of the fodder crop. Even if a few manage to stay in the main crop area they have little chance of surviving because natural enemies are being drawn in from outside to attack them. Meanwhile on the striga side, the *Desmodium* makes sure it does not suppress the maize.

The result of ICIPE's crop management system in 10 districts in Kenya and Uganda was that the maize yield was superior in all cases, and sometimes double, when measured against control plots. Some farmers actually increased maize production by five to ten times on very small farms – a huge difference. In addition, the farmers have fodder, so they can keep more cattle, thereby increasing milk and meat production. These extra benefits make a substantial difference to most of the small farmers, especially the milk production, which brings in cash every day.

Lessons learnt

There are several lessons to be learnt from this.

1. Invasive species can be a major threat to food security. The stemborer from India is only one of a number of insects that have been brought in from other countries, often by scientists.
2. It pays to have access to biodiversity. One day we may need to go back and find beneficial insects or pathogens to control pests, and if we lose biodiversity we may well find we have lost those too.
3. Strategic research in support of applied and adaptive research is a necessity. Knowing the characteristics of plants helps to understand how systems work and how to make them sustainable without the need for external inputs. Production systems that produce fertilizer in the form of nitrogen, create organic matter in the soil, attract natural enemies and maintain the water balance are part of the process of sustainability.
4. Capacity and institution building have contributed to successful programme design and implementation, all as a result of training people who then go on to work in national research and extension systems. Farmers need access to information and that is usually obtained through people, not through research reports, as important as these are.

5. International cooperation can be a key factor for success. It is especially important in science and greatly benefits research.
6. Involving communities, farmers, policy makers, researchers and extension specialists is essential. Policy makers are especially critical for creating a policy environment conducive to sustainable production, affecting issues such as subsidies for fertilizers and pesticides, land tenure and farmers' access to credit, as well as marketing and distribution.
7. Adaptive participatory management methods are required – a vital link between communities and farmers.
8. It takes time and patience to achieve success. Some project examples indicate that it may take ten years to achieve results, but at present the average grant lasts three years. As there are few unrestricted funds available for investigating new avenues, all the money for projects has to be found from grants, usually hard to get and often directed to very specific activities defined by the donors rather than the needs of the end users.
9. There are alternatives to the conventional industrial agriculture model that are sustainable and work (i.e. can feed the world). It is therefore important to consider these alternatives in research, capacity building and extension. It has been said that if all farming were organic we would be unable to feed the world. But the records and data that ICIPE and many other research institutions have published demonstrate that organic and sustainable agriculture can be as productive or more so than conventional methods, particularly bearing in mind the reduced input costs and the assurance of long-term productivity of the land. More research still needs to be done on how these systems can be improved further, to provide not only the food but also the many ecosystem services that are expected from agriculture, such as clean water, air, carbon dioxide sequestration, recreation landscape, pollination, pest control, etc. This again links into appropriate policies.

Vision

Main challenges ahead

- Population growth, from 6 billion to 8 or 9 billion.
- Decreasing productivity of the land.
- Water (quality, quantity, distribution and access). For many people, water may be nearby, but there is no access to it.
- Climate change. We are on a trend that is difficult to reverse. Even if all harmful emissions were

stopped today, we would still go beyond the limit that we should have met. I wonder just what it takes to convince some people that we ought to do something now, when actually we should have taken action 30 years ago when the Club of Rome produced the book *Limits to Growth.* We believed technology would be the answer to all growth-related problems – and we have indeed found some technological fixes, but that is what they are: fixes not solutions. Agriculture in particular will be extremely affected by climate change. There is drought again this year in East Africa and it is going to happen more often. Already one year in four is a drought year.

- Biodiversity crisis. Losses of biodiversity in agricultural systems will have direct impacts on pollination and natural control of pest outbreaks. Some currently proposed solutions for pest control seek a solution in biotechnology and in genetically modified organisms (GMOs). Yet this seeks to further simplify an already dangerously simplified and uniform system. It is of course possible to add genes to crop plants to solve a problem, but the full costs of such technofixes are not yet fully accounted for and will become higher with time, just as we have seen with pesticides. We entered the pesticide treadmill soon after they were introduced, and we are about to take the same path with GMOs, since we are treating symptoms rather than removing the causes of the problem.
- Energy crisis. Again, agriculture will be very much affected, particularly in the developed countries that are using so much fertilizer and nitrogen, the production of which is linked to oil.
- Ecosystem services. We must restore ecosystems and maintain them once they are restored.
- Cheap food policies are a major issue and need to be radically and quickly rethought, as does the food system and its disconnections.

Production equity issues: Let us remind ourselves of food production over the last few decades. Taking the food production index as 100 in 1961, it reached 250 in 2003 – a considerable increase. The problem is that food production per capita, although it has risen, has not gone up by nearly as much, by less than 50 per cent in fact. Food prices, as I have already mentioned, have gone down and keep going down. It is difficult to find an explanation for this, especially at times when there has been a shortage or less food available per person. It certainly defies conventional economics. The trend in undernourished people, which had been falling since 1980, has risen again in the last few years. But we know that today there is in fact enough food in the world to feed everybody well. The trouble is distribution and access, and here may lie the explanation for such low food prices in the industrialized countries where there is overproduction, while many developing nations are hampered by underproduction.

Another problem scientists need to deal with is the gap in cereal yields between high-income and low-income countries. In developed countries productivity has increased steadily, but it is still very low in the poorest countries. Very often the variety of seeds planted, such as hybrid maize, is the same or similar, so the discrepancy is accounted for by differences in access to energy. The potential for higher production exists in developing countries, but it cannot be realized because of systemic factors, such as a lack of production resources or of the financial means to access them.

Although grain yields increased from the 1970s, particularly as a result of the Green Revolution, the trend began to flatten out in the late 1980s and 1990s. This pattern can be seen in China, India, Indonesia and the Philippines and many other countries. The increases were achieved through breeding, some better agronomy and the use of pesticides, but there appear to be limits to how much more we can produce per hectare. Cereal production, however, needs to double in the next 50 years, not because there will be twice as many people – the population will probably increase by a quarter – but because as people have more money they want to eat more, and in particular more meat. It takes a lot of cereals to produce beef.

We also need to deal with the differences around the world. The first of the Millennium Development Goals adopted by the United Nations in 2000 is to eradicate extreme poverty and hunger with a target to halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day. We are behind schedule in meeting this goal. In sub-Saharan Africa there has been little or no change and the same is true of West and Central Asia, Eastern Europe and the former Soviet Union, Oceania and many other areas. People are hungry, and they are also poor. But at what cost are they going to increase production? At the cost of the environment? Or are they going to look for a more sustainable solution?

Sub-Saharan Africa remains the biggest problem because here the number of undernourished people is growing. Everywhere else, except possibly South Asia, it is decreasing. The reasons behind this are many, including diseases such as malaria and HIV/AIDS, as well as the new pattern of extreme droughts. There is also a lack of investment in infrastructure, agriculture, and agricultural research. This is not just a question of money, it is also a matter of training and policy. There is only so much money that can be thrown at the problem; eventually we find it is just buried under the money. In the past, foreign aid was directed at education, universities and technical schools to produce more capable people to manage and to carry out research. Although increasing numbers of people have been trained in Africa, many of them have left the continent. Training must be accompanied by employment creation policies, i.e. investments in the processing industry, thus creating new jobs for excess labour from the farms while also creating markets for farm products. In my view, the developed world is responsible for the current situation in Africa because of the way it has dealt with the problem: throwing money at it and thinking it will go away.

Water issues: Even in the best possible world we are going to need more water, and the only answer is to work harder to make better use of what there is. The Millennium Ecosystem Assessment (MEA) presented four different plausible scenarios for the future: global orchestration; order from strength; adapting mosaic; and techno-gardens. Under all these scenarios, global water availability increases by between 5 and 7 per cent, depending on the scenario, by 2050. But demand for water is projected to grow by between 30 and 85 per cent. Agriculture uses about 70 per cent of total water worldwide, and must be central to all efforts to use water more rationally.

A bit removed from agriculture in the narrow sense, but still an important food source, let us now briefly consider fisheries. There is a belief that there are a lot of fish in the oceans. Actually, yes there used to be, but catches are going down and will continue to do so. Marine fisheries have been declining since the late 1980s. The cod fishery, for example, collapsed in the 1990s and has not recovered. Twenty-five per cent of commercially exploited marine fish stocks are overharvested. Technology has meant that we can catch almost any fish we want. With satellite imagery, big boats, huge nets and trawlers, fishers can harvest and harvest, regardless of replenishment rates. This is a good example of how we must be more sensible about how we use technology, both in the sea and on land.

New perspectives for the future

We need sustainable food systems that:

- Play a critical role in culture and society. Food is not a commodity, but something that people eat and socialize over. Food is also a component of cultural diversity. Farming and farm products are key pillars of the economy. Our economies in both north and south depend on agriculture.
- Play a critical role in maintaining, or restoring, the substance of life. Agriculture is the steward and life support of the Earth, providing water, air, recreation and biodiversity, as well as healthy and nutritious food and an income to a large majority of the people.

If you were to take all the people, the 80 per cent living in rural poverty in Africa and Asia, and put them into cities, how and from what would they live? The food system now developing in the United States and Europe cannot be a solution for the rest of the world.

We need a vision for the future. Can we have something better? I think we can, as long as we have good science and knowledge. There is a lot of knowledge around, not yet turned into theory or written down, which must be nurtured. We also need appropriate technologies, particularly in farming where things are so delicately balanced, and where we can have such a harmful impact if we use the wrong methods. We must learn from the past, and be inclusive in terms of institutions and people. We need to put ourselves within the system much more, where there is a big job to do educating consumers as well as policy makers. We also need adaptive management approaches and constructive policies at the local, national and global levels.

One initiative that may help to provide this vision is the on-going International Assessment of Agricultural Science and Technology for Sustainable Development (IAASTD). This is an international, intergovernmental assessment somewhat similar to the Millennium Ecosystem Assessment[2], but looking specifically at the agricultural sector. It is financed by an international consortium of sponsoring agencies from the United Nations, the World Bank and bilateral donors, including the UK Department for International Development. Actually its name should read agricultural *knowledge*, science and technology – because it is important to include knowledge. The IAASTD will:

- evaluate the relevance, quality and effectiveness of agricultural knowledge, science and technology (AKST);
- evaluate the effectiveness of public and private sector policies and institutional arrangements in relation to AKST;
- create a common vision of the future of agriculture;
- be multi-thematic: nutritional security, livelihoods and human health, and environmental sustainability;
- be multi-spatial: global and sub-global;
- be multi-temporal: short- and long-term perspectives;
- integrate local with institutional knowledge;
- look at policy and institutional issues in light of history and plausible future scenarios.

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[2] www.millenniumassessment.org

The starting point is the four Millennium Ecosystems Assessment scenarios. The scenarios – which have been developed using both quantitative models and qualitative analysis – represent two worlds which are reactive to environmental issues, one more global, one more regional, and two worlds which are proactive, again one more global and one more regional. The people in charge of the IAASTD, from 53 groups, countries, non-governmental organizations and the industry itself, decided that they would also like to see at least one or possibly two more scenarios somewhere in between these two extremes.

What will the world of agriculture look like in the future? There could either be big fields and machinery or farming by hand or, as I believe, something in between, with large differences between regions. Local climate, natural resource and cultural differences and preferences will play a role in the shaping of agricultural systems. The food distribution system also has to be taken into account; will it be very local or very global?

There are 160 authors for the global assessment and another 200 who are writing up the five sub-regional assessments. At the global level, we are thinking about plausible futures and then trying to work out how they could be reached. We are not saying how it will be, but showing what it could be, depending on the choices people make. The main challenge will be for the authors to be really bold and to have a vision. It may be a good idea to involve the next generation in the process and to seek their views on what kind of a world they can imagine living in, as the actual vision will need to come from the dreams and ideas of the young people who will inherit the challenges we have discussed.

I have been talking about sustainable agriculture, I now owe you a definition: I shall use the one that was articulated in 1992 at the Earth Summit: “Farming that makes the best use of nature’s goods and services while not damaging the environment.” It is a short definition and one that has been modified many times since to accommodate all kinds of different wishes. I believe that the original one provides a good basis, and within this framework, there are many interesting possibilities for both producing the food we need and maintaining the production base.

Scale of research to support new visions

I will offer my own thoughts on new visions and the research needed to attain them. Where should the focus of research be to support a viable future for agriculture? There must be a move away from conventional agricultural research, which concentrates on crop breeding and agricultural inputs, towards research that pays more attention to the wider ecosystem and ecosystem services. The same topics reoccur: water, soil, biodiversity, human livelihoods and natural resource self-governance. At the moment research funding tends to concentrate on the molecular issues while ignoring ecology and the wider system. Of what use is a gene without a system in which it can function? Research should be integrated, from the landscape to the molecular, and it is important that everyone has a share of the research agenda.

We certainly have local and global challenges. The impetus for sustainable agriculture originated from localized site-based concerns, but concerns have widened with the realization that unsustainable practices are driving global patterns. High-input agriculture may poison soils with fertilizers, pesticides and salts left from irrigation. Irrigation practices may contribute to the depletion and chemical contamination of surface and groundwater supplies. High-input, large-scale industrial farming practices negatively impact beneficial insects like pollinators and natural enemies, and favour pest populations. There are concerns over energy, production costs, farm productivity against crop yield, and so on.

What are the most viable approaches to these challenges? The current catchphrase is "Think global, act local", but it is arguable that it may be more relevant to "think local" – to look at the problems at the local level and support local community governance – and try to "act global" by developing the systems and policy environment to support the outcomes of research on sustainable agriculture.

What are the likely components of a research agenda for agricultural sustainability? Locally, we need to encourage more site-based research on using components of the natural ecosystem to support agriculture (including on-farm livestock), along the lines of push-pull and pollination services. We need to do research in more sites. If we look at the past, for example in Switzerland, 30 years ago there were about seven agricultural research stations, but now they have collapsed into two. So we are no longer looking at different environments, which is the opposite of what we should be doing. Locally, we also need to develop modalities for more adaptive management, to include researchers, extension specialists, farmers and consumers in the decision-making process.

On a global level, we need to use systems processes to sort out global food security issues. We want to achieve a balance, with each region producing that for which it is best adapted (grains in the north, root crops in the tropics), while developing stronger local and regional sustainable food supply systems. We also need to combine site-based sustainability research with meta-analysis, showing trends across multiple sites.

Externalities must be taken into account in food pricing. Where do we grow our food? Which food items do we ship around and which not? And at what cost? Issues of soil fertility, water availability and access, pest control, pollination and other ecosystem services will only be resolved in the context of supportive public policies, of understanding ecological cycles, and a new approach to governance of natural resources that recognizes that they are actually limited.

The ultimate question is: Is agriculture a commodity or a culture? Jules Pretty's excellent book, *Agri-Culture: Reconnecting People, Land and Nature*[3], reminds us of the importance of agriculture and culture. We have put the two parts together and forgotten about the links between them. Each country wants its own agriculture, and different systems should be maintained as part of culture. There is much to lose if agriculture were to become standardized east to west and north to south, both in terms of culture and in terms of health. There should be more diversity, not more of the same. A further point is that if we want to maintain our environment we have to use it, not for golf courses, which apply many chemicals and produce no food, but to produce food less intensively and with fewer inputs.

One way out of the cheap food syndrome would be to charge people in the cities for the water, the air, the landscape *and* the food. Farmers would be better off if they were paid for everything they produced or maintained, and we could do away with subsidies. People in the cities take their ecosystem services for granted. For cities to have water, someone has to make sure there is land, that it is open and healthy, that there are forests to allow water to drain, and that fertilizers do not pollute it. People in the cities want to spend their weekends in the countryside, so why should they not pay for the spectacle? Or for their air which comes from the forests and the fields? It is the farmer's fields and trees that sequester the carbon emitted from city traffic.

Agriculture and the way we do it have to be completely rethought: "You cannot solve the problem with the same kind of thinking that created the problem." *Albert Einstein.*

Dr Hans Rudolf Herren, President of the Millennium Institute.

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[3] Pretty, J. 2002. *Agri-Culture: Reconnecting People, Land and Nature.* Earthscan, London, 261pp

The changing face of cities

Professor Anne Power

Environment on the Edge

Cities are at the centre of human civilization and invention: even very elementary ancient civilizations worked out ways of gathering people together and then pursuing progress, always around a collection of buildings and people. Out of that emerges an unbelievably complex social and physical structure – the city.

Cities are constantly changing. One of the reasons they change so much is that they generate wealth, but that wealth then tends to destroy its users, partly through the dependency it creates on the wider environment, and partly through the dependency it creates among the poorer people who help to create the wealth. It is a circular process of interdependence, which fails if cities overexploit their surroundings or their people. Throughout history, the story of cities has been of rise and then fall as a result of overexploitation, although we often find this difficult to accept.

The only way cities can gather wealth is by taking it from the surrounding countryside, and in the early stages of city growth that generates wealth. Simultaneously, in generating immense wealth, the environment on which the city depends is being destroyed, as is now being experienced most acutely maybe in fast-growing cities in China. The ancient Mayan and Cambodian civilizations or the relics of Zimbabwean cities make us wonder how and why they rose and fell. Usually, it has been because cities are such vast exploiters of the labour that builds them and the land they use that there is a constant tendency to overreach capacity.

Cities are human and natural structures

There is a constant tension between the man-made nature of cities and the natural environment on which they depend. Are cities part of the natural world, somewhat akin to ant hills or bee hives? Are they a phenomenon that human beings create as part of nature's family home? Or are they something separate from nature, even unnatural? For many, their very decline and destructibility is proof that they are part of nature. The tension between what is man-made and environmentally harmful in cities, and their intrinsic dependence on the natural environment, is one of the biggest problems of modern cities.

Buildings produce 50 per cent of all the carbon that we emit in the United Kingdom, and cities represent by far the biggest collection of buildings and infrastructure. Energy consumption and environmental impact are therefore in the nature of cities, as is the huge waste production that goes with them. Without cities, carbon emissions would not arise at their current intensity and scale. Urban systems that support buildings and infrastructure – transport, trade, production, services, culture – likewise rely on buildings, materials and the energy they consume. Because cities create most of the wealth of modern society, we sometimes forget the vast throughputs on which they rely.

On the other hand, the concentration of buildings in cities makes jobs, schools, transport and other services more accessible and more shared. So it should be possible as a result of collective provision to make cities less energy intensive than their surroundings. In practice the exact opposite is true at the moment.

There have been a number of examples of city systems totally failing. John Reader's book *Cities* (2004) details the mass starvation faced by the city of Berlin in 1917; it was close to a crisis of no return. Today, Berlin stands as a much smaller city, having overreached its environmental and social capacity, having had neither an adequate food supply nor the ability to command the food supply from other people, and so reaching starvation point under the duress of war. The ability to respond to crises is an important aspect of a city's resilience.

In 2000 the river Danube, which straddles 11 countries and flows through several capital cities, reached a tipping point that nobody had anticipated. All the countries along its banks suddenly faced an ecological crisis, not just because fish and plants were dying, but because the level of pollution made the water unusable, putting the cities' water supplies at risk, and reducing drastically the quantity of water flowing downstream. Navigation and river transport were severely curtailed. This vast river that cuts through urban Europe suddenly needed the World Bank, the International Monetary Fund, the European Union and the 11 countries from both Eastern and Western Europe to combine in an attempt to rescue it. Its devastating flooding of central European cities in 2005 only confirmed urban vulnerability to nature, as extraordinary rainfall could no longer be absorbed in the built-over hinterland.

New York also faced a severe ecological crisis in the past few decades, when crime rose to unparalleled levels of violence and killings, and the city came to be considered virtually unmanageable. A critical point arrived when the city could not fund itself, and its water supply was under threat. The sprawl out of New York, partly driven by crime, poverty and urban breakdown, put intolerable stress on the water table and the water supply that fed the city. New York had to change many policies to rectify this crisis, including reworking outer suburban housing developments that would jeopardize the city's water management capacity.

The story of the River Thames in London is well known. Deeply polluted by sewage and industrial pollution until its major clean up in the 1950s, it recently became a sewer again for the first time in decades. In the summer of 2005, the Thames Water Authority was forced on several occasions to release raw sewage into the river to stop the whole vast drainage and sewer network of London from flooding. Thus we can see that even the most sophisticated cities depend on their surrounding environmental resources for their survival. If this is stating the obvious, then cities certainly do not behave as though it is.

Cities are ill-understood predators

We are living in an urbanizing globe, as an increasingly urban species that has been on the march for a very long time. The United Kingdom has been 90 per cent urban since the turn of the 20th century, with 60 per cent of the population living in large cities. Europe as a whole is 80 per cent urban. The world is roughly 50 per cent urban, and by 2030 this proportion will probably rise to 65 per cent. The trend across all human society is toward an increasingly urban order. This is illustrated by the fact that in 1950, less than 1 billion, or a third, of the total world population of 3 billion lived in cities. In 2000 3 billion or half of the 6 billion global population was urban, and by 2030 the urban population will be 5 billion, or nearly two-thirds, out of a total population of 8 billion. It is an accelerating trend. To illustrate the point, in 1980 there were only seven of what the UN calls megacities of over 10 million people, and now there are 20. In 1900 there were only four cities of a million or more, today there are 420.

The huge march of urban change has been driven by two main factors. Problems of land, food and water supply, desertification and population growth have created "push" factors that make it impossible for the rural environment to sustain the populations that were previously held on the land. At the same time there are very big "pull" factors: the attractions of cities, such as freedom, wealth, opportunity and security. Here lies the contradiction: if cities were not wealthier than the countryside, people would not be drawn to them. But making cities wealthier comes with an enormous environmental price extracted from the countryside, thereby driving an accelerating urbanizing trend. It is not clear whether we can enjoy the kind of wealth we enjoy today – which makes cities so appealing – without consuming too many resources.

An interesting consequence of the greater freedom, wealth and opportunity that cities offer is that cities in the developed world are dispersing. As countries get richer, and as they urbanize to a greater and greater extent, so cities spread out, and that is when the real environmental damage takes off. Cities already rely on a huge land area, many multiples of their own footprints, but there is a balance that can be overstepped. London requires 293 times its own land surface area – more than the whole area of Britain – to sustain its huge consumption of energy and resources. This is partly based on Britain's colonial roots and historic, as well as modern, trading relations. Land is a critical factor, for cities cannot survive without viable land.

China has recently become a net food importer as a result of its rapidly advancing urbanization pattern. As more people are now living in cities, so an increasing amount of land that was once agriculturally productive is now being used for cities. Ancient Rome collapsed for many reasons, but a large factor was that it consumed too much forestry and water, and needed to import too much food. It relied on too much land. As cities spread out, incrementally and cumulatively, they use up the environmental resources that they need to support them.

The complex interdependencies of cities and their environments suggest that cities, with their vast agglomerations of power, activity and consumption, are ill understood, and that we barely manage them. Cities on the other hand are remarkably adept at pulling back from the brink. So we may change the way we behave and solve problems as urban pressures grow.

Sprawl leads to neighbourhood decline

One factor that drives the outward movement of urban dwellers is that households tend to become smaller as populations become richer. Households are shrinking unbelievably fast across the developed world and have already done so in the United Kingdom, where the average number of people in a household is now about a third of what it was at the turn of the last century. As a result households multiply with low population growth. That means that three times as much land is required to house the same number of people at the same density of households. However, as standards rise, people want more space per household – for their cars and their gadgets. So density of households falls alongside household growth. Meanwhile, the density of people plummets and the distance between them grows.

Older inner areas of cities constantly shift from being too dense to being too thin. This is one of the biggest problems the United Kingdom faces today and one that is shared to some extent with the rest of Europe, although the continent tends to tolerate greater density. As a result of the decline in manufacturing, there are vast industrial wastelands across the North and Midlands of the country, with used land full of vacant, polluted and derelict spaces. Semi-abandoned, contaminated land, scattered with remaining housing and old warehousing, can be found in the Thames Gateway too, from Fenchurch Street to Southend, looking more like a northern industrial wasteland than part of London.

The phenomenon of urban sprawl brings with it deep neighbourhood polarization and social problems. First of all, the fabric of cities – the buildings that are the creation of man in a natural environment – suffer wear and tear. If they are built like Windsor Castle or Chartres Cathedral, that wear and tear gives them a certain attraction. But if they are old terraced houses they become leaky, and if they are modern concrete blocks, they become rain-streaked and grime-laden, with cold communal areas, allowing the damp in, and warmth out. All this long-term wear and tear on the fabric of cities causes people to move away.

There is a constant urban exodus, with a sifting outwards of better-off people and a holding back of those who cannot afford to move, and then a sifting inwards of poor people who have no choice. Often migrants fill the spaces; from rural areas in the early stages of urbanization, later on Commonwealth migrants and, today, migrants from many different places, including Eastern Europe. The sifting drives the decline of inner areas: slow decay, poorer populations replacing better-off ones, areas becoming unfashionable, and then fewer people. If it is a pressured city, and if reinvestment leads to "gentrification" – upgrading for better-off people – then this decline may turn into recovery on the back of the adaptive mechanisms of cities.

About two-thirds of the United Kingdom is losing population from older urban areas, and the inner cities are losing people faster than anywhere else. Schools, shops and transport deplete because they cannot be sustained – for reasons of low income and population loss. That increases suburban housing demand even when there are enough existing homes. In the North where there is a large surplus of housing, and in the Midlands where there is a smaller surplus, there is still a big demand for new homes in outer suburban areas. Stoke-on-Trent plans to demolish 14,000 terraced properties, which are said to be "unsustainable", and to build 14,000 new houses around the edge of the city on green fields. Burnley and Newcastle have similar strategies. The greater the building of suburban housing, the more the decay of existing areas deepens. If their urban economy is already fragile it can lead to breakdown.

Cities work as dense structures

Density is a critical factor in the viability of cities. Until very recently, including cities in the developing world, density was both a result of the wealth of cities and the cause of it. Density generates urban interchange and urban services. In the United Kingdom in 1900, the average urban density was about 250 homes per hectare, leading to a density of about 1,500 people per hectare, and there was necessarily a strong community spirit. By 1950 density had dropped to 500 people per hectare, a third of previous levels. By 2005 average density was below 35 homes per hectare, around 80 people per hectare, which is below the minimum level of 50 homes per hectare necessary to support a local school, a frequent bus service or local shops. Even in London, where the average density is 45 homes per hectare, there are many areas, particularly eastwards into the Thames Gateway, where the population is too thinly spread to support essential services.

Consider density in this way. It is the density of households that creates housing demand, while it is the density of people that creates services; but household size is down to 2.2 people per home from 6 a century ago. With households at a third of their previous size, there need to be three times the number of households *in the same space* to keep up services, schools, local shops and so on. We must come to terms with the idea that cities work on the back of people density. This cuts across the prevailing reality, of low-density cities and the dominance of cars.

Low density, smaller households and car dominance undermine cities socially. But there is also a physical constraint. The future of cities cannot be built around cars, because the cars just will not fit in on the scale that we currently want to use them. Car ownership expands with household growth, so as households shrink in size and grow in wealth, the number of cars increases per head of the population. This means that cars can no longer easily fit into cities like London. As a result there are now large penalties for parking vehicles where not allowed. It is not worth driving into the centre of the city without a special parking permit. London has had to begin to tame cars in order to fit the people in.

Housing needs to reuse land

Cities require a certain flexibility. In the period of intense urbanization, it seemed acceptable to spread outwards – until we began to run up against energy problems, congestion problems and land-supply problems, to the point where it has become impossible to sustain current land-use patterns. Despite the UK Treasury's intention to meet the building targets of the 2004 Barker Review of Housing Supply in the southeast, we will be unable to deliver them under present scenarios. The Eastern Region water authority and the Environment Agency have confirmed that the target of extra homes for the region is unattainable because of water problems in the Eastern Region. The Kent part of the Thames Gateway faces the same difficulty. Higher density within the existing urban frame of London is therefore inevitable, and not impossible. Our study of the Thames Gateway showed that all the housing that the government wanted for the area could be fitted in the already built-up, low-density London part of the Thames Gateway, which is only about a quarter of the total area.

If we compare land-use patterns across the world, we find that Europe uses on average 6 hectares per person to sustain current levels of consumption, the United States uses 9 hectares and Bangladesh 0.2 hectares. The average land area per person available globally is 2 hectares. As the world urbanizes in an overpopulating globe, then migration, energy intensification, and environmental damage resulting from cities' need for environmental support, are bound to get worse. We have to shrink our land-use needs to one-third of today's in order to survive.

Cities are collective structures. At reasonably high density, the problems are visible enough to demand attention. At low density, spread over distant suburbs, there is a danger that social and ethnic separation, overreliance on cars and overuse of land cumulatively overtake us. For suburbanization lulls the more affluent into comfortable complacency. The resulting inequality and polarization threaten social stability. The biggest worry for the leaders of cities is that inequality and polarization will make cities unmanageable.

Urban recovery is possible

There is huge potential in urban renewal. Cities must have quality homes, a quality environment and quality services in order to retain the people who are currently moving out. But often the best-quality, most attractive homes are old. Renewal is essential for urban survival, and the building blocks for renewal are the neighbourhoods where older homes dominate. Traditionally in the United Kingdom the approach was to get rid of bad housing and build better housing instead, but this is a problematic solution because it is very energy intensive, waste producing and socially polarizing. The poorest people will always lose out and the better-off will move out. The city is left emptier, barer and more polarized as a result. The alternative, which developing-country cities have no choice but to use, is "slum upgrading" and infill development; this is generally much more successful. It has also proved to be a powerful tool in London, the United Kingdom's most built-up city.

One of the problems with urban and neighbourhood renewal is that it can promote the take-over by wealthier people of older, poorer housing with the aim of renovation and upgrading commonly referred to as gentrification. This trend is a common argument against upgrading because "it hurts the poor". However, if poorer people can stay as empty homes are improved, it helps poorer communities recover as well as maximizing the value of underused neighbourhoods. As cities lose population, some low-level gentrification is desirable in order to encourage people to stay: people in work, people who are ambitious for the city, people who demand and are able to organize better services, teachers, health workers and shopkeepers. At the moment, in poor areas of cities, doing up formerly poor housing and attracting better-off people is primarily beneficial, as long as a supply of affordable housing is maintained.

Some people argue that having extremely rich people in poor areas, as is the case in most of inner London, is polarizing in itself. But these mixed communities are a lot better for inner London than having only rich people and pushing all the poor people out, or having only poor people and collapsing services, which is how it once was. The big urban challenge, and London is an acute example of this, is to do what Jane Jacobs argued for – to improve cities within their existing frame without tipping them over from being "mixed" communities into "elite" ones.

If we take seriously the fact that we cannot simply go on using land and energy the way we have in the past, then we have to find ways of making the homes we do have work harder for us. Most existing homes are in city neighbourhoods – using "city" generically to cover all built-up urban areas.

Some 99 per cent of all our homes are already built, but they need upgrading, improving and making more efficient. Even a big demolition programme – much bigger than the slum clearance programme we ran in this country before and after the war, wrecking the cities for 50 years – would not solve the problem of renewal. The largest possible new-build programme along the lines that the UK Treasury is recommending, coupled with the most ambitious slum clearance programme, would still mean that at least 70 per cent of the homes that we will have in 2050 already exist. Since homes emit 27 per cent of all our carbon and are dependent on the other buildings that together emit 50 per cent of all our carbon, we have no choice but to tackle existing homes in existing neighbourhoods. Although the average existing home is extremely inefficient and a new one is much more energy efficient in its use (rather than in the energy it takes to build it), potentially existing homes can be upgraded very easily to save at least half their energy use.

At the moment the United Kingdom has the challenge of 9 million homes with unfilled cavity walls, 20 million underinsulated roofs, 7 million terraced homes, not fully modernized, and 7 million semi-detached houses needing constant upgrading. That is a huge improvement task if we want to make existing neighbourhoods work. Without upgrading the homes that already exist, we cannot reuse the land that lies between the houses, nor the existing infrastructure, which has developed over the 200 years of our recent urban history. Other developed countries face a similar task.

Urban neighbourhoods can help

In thinking about how to tackle the problem of renewal, urban neighbourhoods can be divided into three classes. First comes the top 10 per cent, a small group of "self-regenerating" neighbourhoods, based on high wealth, high-quality collective conditions and services. Kensington, or perhaps Mayfair, epitomize this class of self-regenerating neighbourhoods in London. The second group, covering 70 per cent of neighbourhoods, can be classed as "wear-and-tear" areas. These are gradually declining, with their infrastructure slowly wearing out. Unless there is positive reinvestment, they will eventually become poor. Inner cities and inner and outer suburbs all over the United Kingdom are classic examples of this group. At the bottom are the 20 per cent of neighbourhoods that comprise both private and social housing in decline; these are "collapsing" due to the weight of social and physical problems, and a lack of adequate reinvestment.

Self-regenerating neighbourhoods continue to be nice places to live. They require a high level of services, some of which are paid for by the rest of the city, including the constant in-migration of cheap labour, dependent on the collapsing neighbourhoods for low-cost housing, schools and cheap retail. Self-regenerating neighbourhoods also rely on the "free" wider infrastructure of the city, including roads, transport links, parks and so on. West London has twice the number of parks of East London, for example, and West London parks are always supervised, while East London parks are not. Self-regenerating neighbourhoods consume quite vast resources, particularly in the size of the homes and the space around them. Because they drive the power and wealth creation of the city, they are vital and by tacit agreement we support them.

Yet in Jared Diamond's book *Collapse: How Societies Choose to Fail or Survive* (2005), he talks about a false elite that gets too far removed from the rest of society and is one of the major drivers of collapse. Our cities are potentially extremely divided and we should be aware of the dangers of allowing self-regenerating neighbourhoods to become too remote from the rest of the city.

In wear-and-tear neighbourhoods, 70 per cent of people own their own homes and their own cars, and they depend on and drive the standards of service in their areas. But they often move in search of more space and a better quality of life, and so they inadvertently become the "sprawl promoters". The incentives for them to stay and renew their homes are few. There was a brief period between 1972 and 1978 when generous improvement grants enabled "wear-and-tear" areas to recover quickly, but then the improvement grants stopped and there have been no major re-investment programmes since for average areas. In addition, there are disincentives such as the 17.5 per cent tax (VAT) on all repair and renovation, the fact that urban services such as schools are poorer quality, and urban costs such as transport are higher, as is urban crime. These areas create what I call "urban destructors", named after the Graham Greene story, *The Destructors*, in which an occupied house is sawn away quietly, slowly and invisibly until it suddenly reaches a point of collapse. The wear-and-tear neighbourhoods are in danger of reaching this point, as working people seek better opportunities for their children, often further out of the city, as their neighbourhoods decline.

The third group, the areas that are already collapsing, in fact house our "urban saviours". They house low-income workers, lone-parent families, migrants, minorities. They also house disproportionate numbers of people in real social difficulty. Concentrating problems in poor areas is a common solution to wider social problems, but it creates additional strains on already pressured communities. It is difficult to know what else to do – high-value areas do not accept this social burden. Collapsing areas are thus the very areas that rescue the most needy casualties of city competition from destitution.

Collapsing neighbourhoods depend heavily on public services, which they also help provide. They are used by the wider city as a "dump" for the problems it does not want and as a resource for the workers it does want. These areas often have deeply damaged environments. East London, for example, is covered with giant electric pylons; since the area was only housing the workers of the city when it was built up, burying the pylons was not considered necessary. The government has just announced that it cannot afford to bury the pylons in Thames Gateway, except for the Olympic site.

Poorer areas have negative impacts on the city while performing an invaluable service at the same time. The reinvestment costs to bring them up to a reasonable standard are way beyond the means of the people who live here. Yet in urban and house-building terms the costs are relatively modest compared with building a new home, somewhere between £10,000 and £50,000 (around $20,000-100,000) for renovating and upgrading each home, far cheaper than building anew. But it is also more complex, because it is more difficult to work around people already resident in an area, and buildings already in place; this is one reason why demolition is often preferred. Yet we have no choice but to upgrade "collapsing neighbourhoods" in a crowded country that is short of affordable housing, and various government programmes reflect this ambition. However, the incentives are not there.

Jared Diamond identified five factors in the collapse of societies: environmental damage; climate change, related both to natural causes and to high energy use; hostile relations with neighbours and the generation of violence; diminishing support and increasing isolation; and the failure of society to respond to the problems. I would argue that our response to poorer neighbourhoods within cities echoes this threat. Perhaps we need to worry about the 70 per cent "wear-and-tear" neighbourhoods and the 20 per cent "collapsing" neighbourhoods, as opposed to the 10 per cent high-quality "self-regenerating" areas.

Transfer of environmental resources from new build to existing communities

In order to cut carbon use by 60 per cent we have to renew existing houses and neighbourhoods. There is agreement, among top architects like Norman Foster and Richard Rogers, and engineers like Arup, that energy saving in buildings is relatively easy to do. The estimated total cost of upgrading the whole stock of 22 million homes to "excellent" efficiency standards, is around £200 billion ($380 billion), half the annual Treasury budget. Obviously such costs would have to be spread over many years, but it could be achieved over 30 years by diverting the Treasury's indirect subsidy of £35,000 ($65,000) to each new-build home. If the cost of the new infrastructure and the environmental impact of new homes was charged to the developers, as is increasingly being discussed, then that charge could upgrade three existing homes to high energy efficiency standards for every new home built. In order to fund the push in favour of existing communities, we must start charging the true costs of building on the urban edge. Land value multiplies manyfold through development, often by a factor of five to tenfold in low value areas, many thousandfold in parts of the southeast. The Urban Task Force, chaired by Richard Rogers, in 1999 recommended such a charge, and the proposals in the Barker Review for a "development" levy echo the need for an environmental and infrastructure charge.

Renewing existing homes and communities would increase the density of existing built-up areas, leading to social integration; reductions in land use, energy and transport; urban viability. It would maximize the value of the existing infrastructure, a huge cost saving; it would renew existing neighbourhoods by attracting new resources and renovating buildings while reducing energy use and waste; and it would revalue existing older property. This would in turn attract investors to small abandoned sites scattered liberally within existing neighbourhoods.

In London, where there is little choice and there is a major affordability crisis, density is increasing without too much effort. The Mayor of London has now asked all London boroughs to do capacity studies, not for the bigger sites which are well plotted, and of which there are hundreds, but for the sites of half an acre and below, where perhaps four or ten or even 20 flats could be built, and through which projected housing demand in London could more than be met. There are hundreds of thousands of these sites, offering the capacity to add all the extra homes we need within the existing urban frame.

All space is now contested. Whatever the faults of the current planning system, the need for planning is itself wedded to the idea of making a social compact about how we live together on a crowded island. The civilization of cities requires us to live together with some agreed norms, systems and exchanges that neither infringe other people's freedom nor allow abuse and conflict to spill over. The contested spaces of cities actually work through managing proximity in a fast-changing and increasingly mobile globe. One of the reasons why people spread out from cities, yet remain attached to them for work, culture, social life and economic growth, is the tension between freedom and constraint. It is one of the reasons why people still adhere to the idea of community. City communities require close, but "soft" as well as "hard", management.

Can cities become sustainable?

There are some amazing examples of urban renewal. Barcelona won back its position as a thriving city through an open spaces plan – a kind of post-Franco gift to the people of Catalonia. The city authorities set about creating open spaces, however small, in 140 neighbourhoods throughout the most dense city in Europe, involving residents on the one hand and urban designers on the other. By 1984 they had created so many attractive neighbourhood spaces, with so much support from the citizens of Barcelona, that they were able to back a very persuasive bid for the Olympics. It is one of the few Olympic bids, if not the only one, that returned profitability and positive assets to the host city.

In Curitiba in Brazil, the authorities took a very distinctive approach, which has become a global model for urban transport and urban sustainability. The Mayor decided to turn main access roads to the centre into express bus-only routes, creating traffic-calmed pedestrian spaces in the centre. Cars would no longer be necessary, thanks to a complex local bus network linking all neighbourhoods with the main express bus routes. A unified bus fare ensured that the poorest people living in shanty towns on the edge of the city, often essential service workers, could get into the city for the same price as richer people living much nearer the centre. The environmental and social improvements in the city ran in parallel.

In Copenhagen, one-third of all people go to work by bike, and 25 per cent of the city's and the country's energy comes from windmills. The city has worked on this agenda for 25 years, holding stable the number of cars in the city and pushing up walking and biking.

Even London, for all its problems, has transformed its centre with the congestion charge, taming traffic, doubling the level of cycling, expanding bus ridership by 40 per cent over two years. Manchester, having been the urban pit of the country for many years, has turned its industrial heritage into World Heritage. But it also discovered that becoming the greenest city in the country is emblematic of the future. With the most intensely depleted inner city and the largest supply of brownfield sites, it is overtaking Birmingham as the leading core city in recovery.

An urban globe

At the moment natural capital is uncosted or undercosted as a result of poorer countries of the world selling their environmental capital too cheaply, so that European and American urban and suburban dwellers can consume it at a rate that far exceeds the planet's carrying capacity. The developed world will not survive the level of migration that will result from the unfair trading of natural capital between poor and rich countries. Professor Sir Partha Dasgupta of Cambridge University argues that we cannot continue to overconsume in the urbanized West the natural capital that belongs to all without unravelling social and environmental conditions across the world. For we all depend on sharing natural capital. Dire environmental consequences are forecast for poorer countries, that are already experiencing serious migration from environmentally stressed areas. Deforestation, soil depletion, drought and desertification are just some creeping indicators of this global disaster.

We do not protest at knocking down houses and using the old, baked bricks for underlaying roads; yet crunching up baked bricks for hard core is a tragic waste of the intense heat that went into producing those bricks and homes. Most of the bricks in our houses in the United Kingdom have hundreds of years of life in them. So we have to change the way we think about recycling and renewing. If we can recycle plastic bags, we can surely recycle homes. In an urban globe, it makes sense to reuse everything we can that we have already put into urban building.

Urbanization is continuing apace in any event; all attempts to prevent or slow the growth in the world's cities have failed. Therefore, recycling and renewing our cities is crucial, given the environmental impact of cities and their ultimate dependence on nature. We have a long way to go, but the intention is growing to put the urban environment to right for the sake of our social as well as physical survival.

Professor Anne Power, of Social Policy at the London School of Economics.

Women and conservation

Kathryn Fuller

Environment on the Edge

During my career in conservation, some 20 odd years, I have had the opportunity to run a large international organization and to serve on a variety of boards, and to raise a family. While the trade-offs and the balancing act have always been somewhat challenging, and my role as a woman leader in conservation is somewhat unusual, I have never felt that society has placed any limits on me. My limits have been, as far as I have seen it, simply my own.

But the situation for women in many parts of the world is very different. Family and community traditions and expectations place real barriers in the way of women seeking to work on conservation issues. They face opposition, even ostracism, when they step out of conventional roles, and yet they do so, and do so effectively. Exploring their accomplishments and backgrounds and motivations has always seemed to me very important to understanding what it takes to achieve conservation results for the long term. Setting aside the role of women, though, I would like to give a sense of the seriousness of the conservation challenge, a challenge that has not lessened since I got involved a few decades back.

And indeed I would posit that it may be the greatest challenge that we humans face because the sad truth is that the natural world is everywhere disappearing before our eyes – more than 6 billion people with a predicted 9 billion in the decades ahead. We are simply too many, with large numbers of poor struggling to raise the quality of their lives in any way they can, and the fewer affluent who consume so much of nature's bounty. The litany is familiar to us all. Half the great tropical forests have been cleared. Species of plants and animals are disappearing a hundred times or so faster than before the coming of humanity. We have driven atmospheric carbon dioxide to the highest levels in at least 200,000 years, and contributed to a global warming that will ultimately be bad news everywhere.

Forests, freshwater and marine systems alike are suffering. The world's forests reached their maximum extent 6,000 to 8,000 years ago, around the dawn of agriculture and the retreat of continental glaciers. Today, with the spread of agriculture, only about half that forest cover remains, and it is being cut at an accelerating rate. Over 60 per cent of temperate hardwood and mixed forest has been lost, 30 per cent of coniferous forest, 45 per cent of tropical rainforest and 75 per cent of tropical dry forest. And half of the surviving forest has been degraded, much of it severely. As forest habitats shrink so does the number of animal and plant species. Conservation biologists use a rule of thumb that if habitat is reduced to one tenth of its original size, animal and plant species decline by about one half. So removal of the final 10 per cent can wipe out the remaining half in a stroke.

The largest remaining intact areas of forest include the needle-leaf forests of Canada and Russia and the rainforests of the Congo Basin and New Guinea, and largest of all the Amazon. Vast as it is, though, even the expanse of Amazonian rainforests is not safe. With trees anchored by shallow root systems, and easily bulldozed then sawn into lumber or chopped and burned to make way for crops, Amazonian forests could disappear within decades. About 14 per cent has already been converted to other uses and Brazil, which holds two-thirds of the Amazon, has set aside only a modest 3 per cent in protected reserves.

To the extent that the Amazon is cut and burned, annual rainfall also declines, far beyond the Amazon Basin itself, and the wilderness remnants within the region are stressed still more. Models of the whole cutting process suggest that a tipping point could cause the forest to collapse, turning much of it into dry scrubland, with consequences for rainfall within the Amazon, within South America and across the oceans.

Freshwater systems in fact may be even more imperilled. Across the northern third of the planet, the most densely populated and industrialized, we have converted almost all large rivers with dams and channels. Some are dammed along their entire length and those running through drylands are substantially modified. Not only do we take nearly all the water from some rivers, we pollute them with an array of by-products from agriculture and industry, and that effluent in turn flows into the oceans.

Rivers, lakes and freshwater wetlands are hugely important biologically. While they contain only 0.01 per cent of the planet's water they hold a much larger fraction of the Earth's species. In fact, freshwater fishes alone comprise about 25 per cent of all of those vertebrate species that have been described scientifically. Scientists tell us that, because their habitats are so vulnerable, freshwater species face an extinction risk about five times greater than that for terrestrial animals. And freshwater scarcity is looming as a huge problem around the world. Oceans too are showing signs of abuse from poorly planned coastal development, burgeoning tourism, overexploitation of marine resources and global warming. And unlike on land, the establishment of parks and protected areas in the marine environment is still a relatively new concept in much of the world.

Of the world's coral reefs almost 60 per cent are threatened by human activity and 10 per cent may be damaged beyond recovery. And that, I think, is a conservative estimate. We have lost half the world's coastal wetlands in the last century. Seagrass beds, among the most productive sea-life nurseries, are in retreat along virtually all inhabited coastal areas. Close to 70 per cent of the world's beaches are eroding at higher than historic rates.

Fishers go everywhere, from the dwindling pack ice of the Arctic to the pack ice of Antarctica, in winter and in summer. With today's sophisticated modern technology, virtually no potential fishery is too remote. Not only are 70 per cent of fisheries overexploited, or on the verge of becoming overfished, they also waste huge amounts of unwanted fish and other animals, so called bycatch, and physically damage the ocean floor. The oceanic fish catch now yields $2.5 billion to the US economy and over $80 billion worldwide. But research reported in the *Financial Times* states that catch is down by half compared to 50 years ago, even though the effort to harvest those fish is up threefold and the energy used in the process is up tenfold.

Aquaculture takes up part of the slack, but at rising environmental cost, converting wetlands – valuable wild fish nurseries – into ponds, using fodder diverted from crop production, and often producing substantial pollution.

As these background comments suggest, a number of factors converge to produce alarming losses to the natural wealth of our planet – sheer human numbers, increasing rates of consumption in developed and developing countries alike, and the globalization of the market place. Let me give an example to illustrate just how these factors can play out, and how far-reaching our approaches to the conservation of nature have to be.

The Tesso Nilo Lowland Forest of Riau Province, on the island of Sumatra, has been called the Earth's richest forest for vascular plants, and is home to endangered elephants, tigers and orangutans. Industrial exploitation has already wiped out vast pockets of forest in Sumatra and converted them to fast-growing tree and oil-palm plantations. Protecting the remainder has become a race against time. A Tesso Nilo tree travels widely. An Indonesian company, APRIL, logs and pulps it. A Finnish company, UPM, turns it into paper in China. America's International Paper sells it to Hewlett Packard, which in turn sells it to consumers around the world for home and office printing. Along the way the governments of Germany, the United States of America, Austria and Japan, among others, provide export credits to their machine manufacturers to install pulping and paper-making machines in the various mills that handle the tree.

So protecting the forests of Tesso Nilo, and the wildlife that the forest contains, requires not only community engagement and activism, stepped up poaching patrols and park status, but also identifying the chain of investors, creditors, financial advisors, processors, merchants and consumers who handle the tree. It means engaging them one by one from the ground to the international arena, telling the story of Tesso Nilo and involving everybody in the effort to protect the forest that remains. While Tesso Nilo remains at risk, the good news is that a park has finally been created and a corporate exploiter has now become an ally.

So finding nature conservation solutions – truly durable and effective solutions – requires operating at multiple scales and through multiple disciplines, from the local community to the multi-national agency or company, through expertise and development biology, economics, law and so forth.

Prompting action in the face of such daunting challenges can be difficult, especially when many people react to warnings of resource depletion and pollution with apathy or despair. So showcasing success stories, demonstrating that individual and community initiatives can truly make a difference, provides a message of hope and a stimulus to take on issues that may otherwise seem overwhelming. And it is the importance of success stories that brings me back to the role of women.

In many instances it is women who, often in unassuming fashion, effect major changes in the way their communities use forests, fisheries and water. In Tesso Nilo, in fact, a young woman from Riau, Sisi Mariachi, has played a pivotal role. She went to college to study communications and then returned to her community to promote the creation of a national park, working with both community members and government agencies. Last year, as a result of the lobbying efforts and long-term investments of all sorts of human and financial resources, the Tesso Nilo National Park became a reality. This young woman now leads the effort to implement new management practices in and around the Park. She also travels through Jakarta regularly to advocate for the Park with the national government. All of this is no small feat for somebody who started life in a village, and is now 30 years old and raising two small children as a single mother.

The critical role of local women was vividly born out for me early in my time at WWF when I had the opportunity to witness one of nature's truly grand spectacles – the migration of the monarch butterflies. As you may know, the monarch butterflies from east of the Rocky Mountains migrate thousands of kilometres south, to their over-wintering sites in the mountains about 80 kilometres west of Mexico City. And it is hard to describe what an overwhelming and really very moving sight it is. The oyamel fir trees on which the butterflies congregate over the winter are so covered that you cannot even see the trees, and when the sun comes out and the butterflies warm up they begin to fly off the trees, cascading in amazing patterns. The only thing you can hear is the sound of their wings.

But at the same time that this remarkable spectacle is moving and inspiring, you cannot ignore the reality of what is around it. It is a hilly, rutted area where people, largely women, are ploughing the fields to plant corn on extremely steep and eroded slopes, and all around them as they plant are fluttering the monarch butterflies. So why was the confluence of these images so important to me? Well, the monarchs' habitat has come under increasing pressure in recent years from the growing human population and increased demand for commercial timber and firewood. The destruction of the monarchs' habitat to fuel this demand, though, is also eroding the landscape and leaving local people with nothing to look forward to but an impoverished future. It was a no-win situation for people and monarchs alike.

As tough as their lots were, the women I encountered there were nonetheless taking conservation action. One woman, with her long braids and maybe eight or ten children, explained, as she tended both her children and a field, that if the forest disappeared nothing would be left for her children and those to follow. And so she, and the other local women, had broken with tradition and begun to work with a local tree nursery, funded and supported by a Mexican conservation organization. Involving their families in tree planting, the women worked to bring about acceptance of the tree nursery by the full community. Since forestry was traditionally a male enterprise, these efforts represented quite a break from local tradition and initially aroused a fair amount of community criticism. It had been very difficult, said this woman, to step outside a traditional female role. But the importance for the future made it worth it, along with the fact that they could see within ten years' time the beginnings of significant change in forest protection and regeneration.

It is not surprising that these women in and around the monarch reserve have such a keen sense of the importance of protecting their forests. Like their counterparts elsewhere, it is women in many cases who are in closest contact with the land. Women are the world's farmers to a large extent, producing almost 60 per cent of all food grown and consumed locally. They plant crops, gather firewood, tend animals, bring in water. They carry out all the tasks that allow families to survive from day to day. There is indeed a lot of truth in the old adage, "a woman's work is never done". From dawn until well after dusk, in fields and forests, and in the home, their toil is difficult and lengthy.

In Tanzania, for example, women work on average more than 3,000 hours a year, compared to a little more than 1,800 hours for men, and that burden only grows as more and more men migrate to the cities for employment, leaving women behind to manage everything else in miserable conditions and frequently on meagre diets. Consider these statistics: by some estimates women perform two-thirds of the world's work, but receive only 10 per cent of the world's income and own just 1 per cent of the world's land. That is another way of saying that their labour is invisible, ignored by the formal economy. And without access to credit, education, training and technology, their situation only worsens. As that happens the pressure on them, and on their natural resources, only increases.

It is these women themselves who are the biggest victims of environmental degradation. As providers and carers they depend on the renewability of natural systems to meet their basic needs for food, water and shelter. As the soil erodes they cannot plant the crops to feed their families. If lakes and streams dry up they must walk longer distances to secure precious water. Forests disappear, and they lose not just fuel, wood and fodder, but also fruits and nuts – an important source of extra income but also, more basically, protein.

In addition, local women typically have been excluded from decision-making bodies, from village councils to the halls of national governments. Men, for the most part, are the ones who are shaping economic and political policy. And until recently even conservation, development and environmental groups have largely ignored, or not fully appreciated, the role that local women play in the conservation struggle. So, for example, in the Gambia in West Africa, when conservationists and government officials came together to create a new park, they agreed to abolish the traditional access of women collectors to oyster shells in the mangrove swamps around this park. The lime from burning the shells was then used to construct a new park headquarters. This, though, took place at the cost of the women who had traditionally sold the lime to local builders and used it to support themselves and their families.

These obstacles have not stopped women from taking action. Faced with necessity they take on the complex task of shaping conservation attitudes and practices, often without wanting or seeking recognition from others. Scholars who look at questions of women's leadership note this characteristic – not in all cases, but in many – of self-effacement. They say that women's approaches to bringing about change are frequently different from men's, especially at the grass roots, not from inherent characteristics, but from the life experiences and cultures in which these women have grown up.

In order to avoid negative reactions from families and communities women who take on non-traditional activities underscore their roles as wives and mothers, and the need to address threats to family and to community. As one writer notes, their activism "closely resembles housework". Indeed, women who bring about dramatic change frequently do not consider themselves leaders. Nor do they fashion themselves as bold or charismatic visionaries. They prefer to mobilize collective action, rather than to emphasize individual accomplishment.

In this way their work not only deflects criticism but also becomes more deeply embedded in the values and behaviours of the community. One of the best known and most inspiring examples of women taking collective action in conservation comes from India, where some 30 years ago women from the Chamoli district faced the loss of their forest to loggers. They knew this would mean the loss of their forage and fuel and would increase their vulnerability to catastrophic flooding. So when the first loggers arrived, the women went into the forest, joined hands, and encircled the trees. They told the loggers that anyone who wanted to cut down a tree would first have to cut off a woman's head. The result? The loggers withdrew, and the forest was saved.

That courageous act of "chipko", or hugging, became an extremely powerful symbol. Out of that initial protest grew a movement that spread throughout the Himalayan region. Local activists – men and women alike – now trek hundreds of miles to educate other villages about the importance of preserving their forests.

As I prepared to step down from WWF last year, I wanted to dig more deeply into the ways women are individually and collectively engaged in bringing about positive conservation change. I have had the good fortune to be able to do so over the past several months as a public policy scholar at the Woodrow Wilson International Center for Scholars in Washington DC.

My project there has involved looking at similarities and differences in the stories of local women from different parts of the world. Are these women alike in the ways they tackle problems? Are their motivations the same? Did they choose the path or did the path choose them? What skills did they bring to their activism and what skills did they have to acquire? What costs have they incurred and how have they changed as individuals? Where are they now and where do they see themselves in the future?

Women who have collaborated on the projects of WWF and partner organizations provided a rich pool. These are not women who are celebrated internationally, although certainly global leaders in this arena exist, most notably the Nobel Prize laureate Wangari Maathai, whose vision and determination propelled the "Green Belt" tree-planting movement that transformed Kenyan landscapes.

Some of these women have received college educations, others not. Some have stayed rooted in their communities, while others have broadened their ambits and ambitions following upon local success. All, however, have truly made a difference in conservation. Here are a few examples.

Zeinab Musa is a young Muslim woman in her 20s who chafed as a girl under the constraints of local custom. One of nine children from a small Kenyan village not far from the Somali border, Zeinab had few prospects. Education was not a priority in her village and in any case girls there seldom went to school. Zeinab was ambitious, though, and decided to get an education one way or another. Sneaking out of her family's home, she would follow her three brothers to school and sit beside a window with the lessons being taught inside. After a few weeks of this, one of her brothers brought her into the classroom, where, at mid-year without books or a uniform, she was able to begin her studies in earnest.

Zeinab not only caught up with the other students, but excelled. She went on to college, received a diploma in science education, and returned to her home village in order to give something back to others in the community. She soon found work for WWF on a conservation education and awareness project on the Kiunga Marine Reserve, a recently established protected area made up of small islands, coral reefs, turtle nesting beaches and mangroves. The Muslim communities there have few economic opportunities and depend heavily on fish and other marine life for their livelihoods.

Zeinab's work has focused on young people, especially girls, involving them in coral transplants, resource management and environmental awareness. "By supporting girls you are improving a household," said Zeinab. "Before, the girls could never imagine that there would be a woman working in the field of conservation. They admire and appreciate what I am doing… Girls need to be brought up to learn they can do more."

That education and awareness work led in turn to an innovation that has both bettered the local environment and provided a new source of income. Trash was accumulating in great volume along the beaches, the bulk of it made up of discarded sandals carried by the currents from across the Indian Ocean. As part of a beach clean-up initiative, the children began collecting the sandals and other debris. The community women then turned the sandals into handbags, key rings and other crafts. The items have been sold in the region and beyond – all the way to Nairobi and even to international markets – and for the first time the women have found themselves with income at their disposal.

While marketing remains a challenge, the project has provided multiple benefits to the community. A hygiene problem has been reduced, turtles can more easily nest and their hatchlings more easily reach the water, the cleaner beaches hold promise for attracting ecotourists, and the women of the community have found a way to bring in funds for their families. Zeinab herself has now had a number of opportunities to travel and to continue her education, but she has stayed rooted in her community where her work continues to focus on environmental issues.

Half a world away, in the rolling hills of rural northeastern Oregon in the United States, Diane Snyder works to protect and manage community forests. Diane is a fourth generation rancher from Wallowa County whose commitment to the land runs deep. She has served as Executive Director of

Wallowa Resources since the organization was founded 10 years ago to promote forest and watershed health and to create family jobs and business opportunities from natural resource stewardship.

Like many other western communities at the time, the Wallowa County logging industry was at a crossroads as a result of changes in environmental legislation, depleted timber supplies, and new technologies. Sawmills were closing, jobs were disappearing, and many families had begun to move out. The ranching business was also in decline. Schools even cut back to four days a week because the tax base had dropped so sharply.

The tensions between environmentalists and the timber business ran high, pitting neighbour against neighbour, classmate against classmate. Environmentalists were burned in effigy. As a rancher who considered herself an environmentalist, Diane Snyder felt she had to do something to bridge the divide. She was in her 30s at the time, married and with a daughter, and did not think of herself as a leader or particularly qualified to mediate conflict or find solutions. “I am a native of Wallowa with a high school degree. I sometimes feel that I’m not smart, because I don’t have a diploma on my wall,” she said.

And yet she knew she had to take action. Using her skills as a good listener and storyteller, Diane began organizing community meetings with the help of a regional organization, Sustainable Northwest. As a fourth generation native, she was trusted and respected, even when her personal views were not shared by others.

The Wallowa Resources organization emerged from these community meetings and quickly became influential. The county commissioners recruited the organization to implement its economic development strategy, and the US Forest Service entered into a cooperative agreement with it to demonstrate new watershed management approaches. Working with public, private and tribal landowners, Wallowa Resources has spearheaded stream improvements, undertaken wildlife and native vegetation restoration, and developed training and education initiatives for children and adults. As the various groups in the county began to work together, the deep hostility that had divided them largely dissipated.

The rapid success of Wallowa Resources began to attract state and national interest as a model, and Diane soon found herself travelling and speaking widely. This recognition came with personal costs, however. Local residents began to wonder if she had got too big for her home town and she faced tensions within her family.

Diane responded quickly. She made a point of building a strong team within Wallowa Resources which could share both leadership responsibilities and travel, and carefully limited her own. And despite the continued requests for her involvement in initiatives outside the region, she made it clear that her family and Wallowa County remain her enduring priorities. For Diane Snyder, satisfaction in life comes from an an unbroken connection to place.

Returning to another example from the developing world, Sushila Nepali did not grow up in a rural setting, but rather in Nepal's capital, Kathmandu. She had a strong interest in working in local communities and in the natural world from her early school days, however.

As Sushila approached college age, she thought about focusing her interest in biology by pursuing studies at Nepal's forestry school. There was one problem, though, she noted: "Forestry school was only for the men." But Sushila was undeterred. She made a success of her studies and then followed her heart into the field, working along Nepal's border with India in what is called the "Terai Arc", a landscape of dry forests that harbours tigers, rhinos and elephants. The Terai Arc is also home to a number of poor indigenous groups struggling to survive alongside wildlife and forests that nature conservationists have identified as a priority for protection.

Sushila's job was to work with the communities on finding ways for wildlife and people to co-exist. The work was hard, but gratifying, she says, and in some ways made easier by the fact that she was a young woman. "I can go into a village and talk to the people more openly than the men do," she commented. "Men might not be able to talk to the women of a village, whereas I can talk to both men and women." Nonetheless, it took time for Sushila to gain acceptance by the local women, even to have them call her by name. "Before the women talk to you openly, they need to see you as a person. I have to just be me."

Having devoted the time to listening, learning and becoming trusted, Sushila's project began to take off, with the participation of men and women alike. Critical forests were restored through natural regeneration and plantations, forest users' groups came together to resolve conflicts, the communities stepped up anti-poaching efforts, and they began to feel they had an increasing stake in, and control over, forests and other natural resources.

Having spent time myself with the women in some of these Terai communities, I had the chance to see first-hand how local women have become engaged in active conservation work there, both in order to take advantage of the opportunities the project offers in the acquisition of new skills in sewing and crafts production, and also because they had become more aware of their dependence on healthy forests and the need to take personal action to protect them.

Sushila Nepali returned to Kathmandu after some years in the field to work with WWF on getting the successes of the Terai Arc work more broadly known and the model applied throughout the region. She now pursues PhD studies in Nepal and plans to continue a career in conservation. While she takes pride in her own contributions, Sushila's bottom line is that the women from the villages are now writing their own work plans and proposals and have an abiding sense of their own capacity to improve their families' lives and to protect their forest and wildlife.

Stories like Zeinab Musa's, Diane Snyder's, Sushila Nepali's and the women with whom they have worked underscore the importance to conversation success of including local women in conservation initiatives. In much of the rural world, in developing and developed countries alike, women are in the majority and are closest to the land. It is they who see the erosion of soils, the despoiling and scarcity of water and the loss of forests as they go about the hard work of their daily lives.

To recognize the importance of women and their special link to the environment, however, is only part of the answer. Bringing about community engagement in conservation always requires much patience, good listening skills, and sensitivity to cultural nuances. That only becomes more complex where women are involved. Women typically do not play leadership roles politically in their communities or in the forestry and fishery sectors. Bringing their perspectives and skills into the mix requires working around their demanding schedules tending to children and animals, gardening, cooking and cleaning. A community meeting called for mid-day simply will not draw women who are busy well into the evening hours. And meeting with women typically requires going to them, for women often cannot go far from sleeping children or a fire they are tending.

In addition, the way that women become involved and the vocabulary for describing their involvement often needs to be different from what is prevalent in the wider world. A woman urged to become a "leader" in a conservation initiative because of her good reputation for getting things done in the community may well shy away. "Leadership" by a woman may evoke hostility from family and community and lead to difficulties for the woman and the conservation initiative alike.

This means that governments and conservation groups planning conservation programmes need to make a special point not just of inviting the participation of women, but of finding the most effective ways of securing it – understanding their role in the community, recognizing their special constraints, finding ways to ease their participation, supporting their access to education, helping them to secure better income through micro-credit and other options, and ensuring that the full community sees the project as inclusive and transparent. And then they need to monitor and evaluate their projects, including the role of women, to get the word out about what has worked and what has not.

Communication, it seems to me, is critical. If we can get these powerful, yet little celebrated examples more broadly known, we will not only underscore the distinctive and important role of women in conservation, but also may capture imaginations and inspire others to step forward. Changing practices at the community level does not fully address the complex challenges of protecting the biosphere, to be sure, but is one essential starting point. To repeat a well known quote from the anthropologist Margaret Mead: "Never doubt that a small group of thoughtful, committed people can change the world: indeed, it's the only thing that ever has!"

Kathryn Fuller, Chairman of the Board of the Ford Foundation.

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